SANITARY PLUMBING

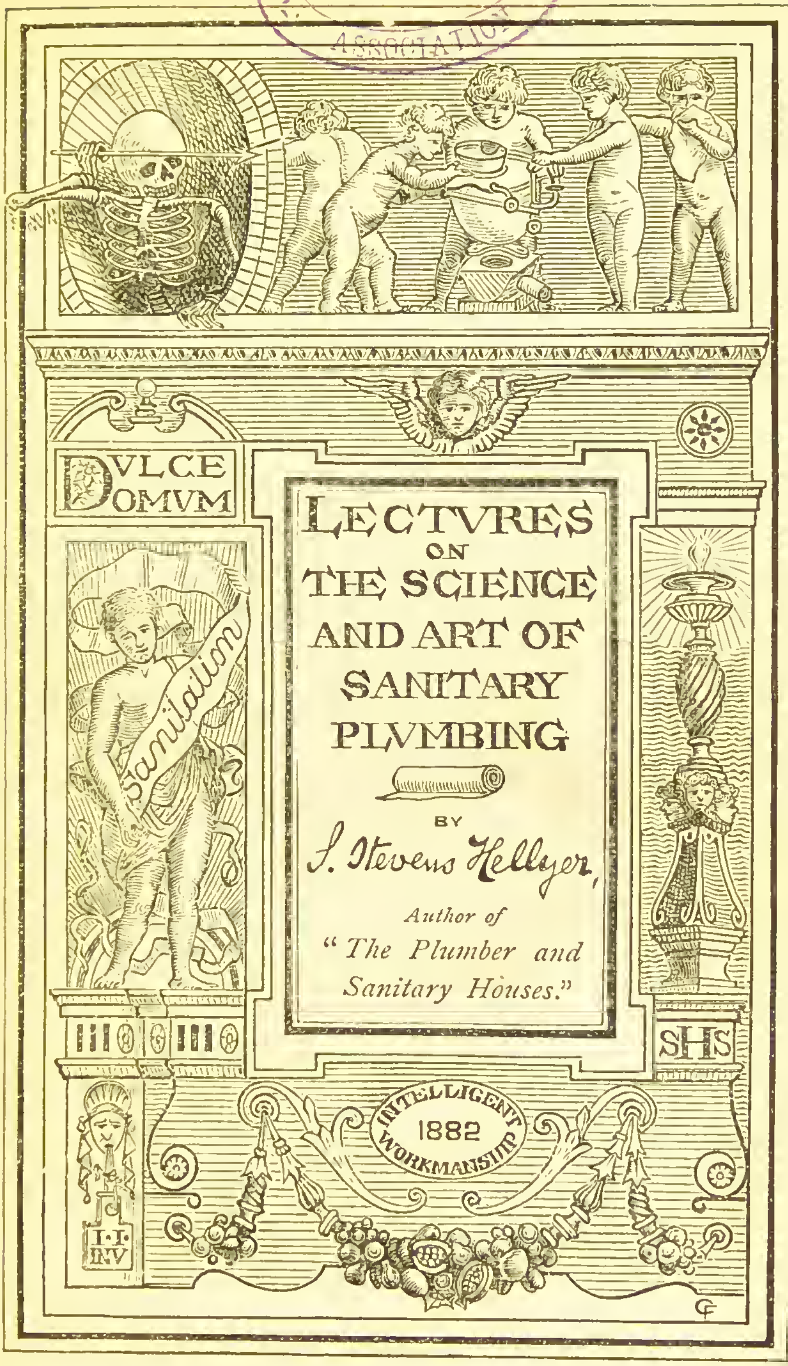
S. STEVENS HELLYER

from the Author.

THE SCIENCE AND ART

OF

SANITARY PLUMBING.



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Dedicated

TO THE NATIONAL HEALTH SOCIETY,

WHOSE WIDE SYMPATHIES EMBRACE ALL SANITARY SUBJECTS,

AND WHOSE MOTTO,

"PREVENTION IS BETTER THAN CURE,"

These Lectures

ARE INTENDED TO EXEMPLIFY.

PREFACE.

WHEN sending out the enlarged edition of "Dulce 'Domum,'" about a year ago, I had no idea of sending out another book, at any rate so soon, for seeing a book through the *press* is quite a different thing to seeing a parcel of lead through a pipe-press, or rolling-mills; for, though the sheets from the latter may be "weightier" matter, the sheets from the former are no light affair, especially when covered with *figures*, for elucidating the text, and to which constant reference has to be made.

In the early part of this year I was requested by the National Health Society (of 44, Berners Street, Oxford Street) to give a Course of Lectures to Plumbers, and these lectures—which are here published — were delivered during the summer months at the Hall of the Society of Arts, John

Street, Adelphi, by the kind permission of the Council.

The lectures excited so much interest, that they had to be re-delivered, and, notwithstanding the full reports which appeared in the papers and journals, I have been urgently pressed to publish them in book-form—which I now do—hoping they may be helpful to many, if not interesting to all, makers of houses.

I may say that a colloquial style has been followed, the lectures being printed practically as they were delivered (excepting that a great deal of new matter has been added); besides, the subject, though treating of the *water-carriage* system, is only a *dry* one at the best.

Though I have been anxious to keep the cost of the book down, to put it within the reach of the poorest village plumber, journeyman, improver, and apprentice, I have, at the same time, been desirous to have it well illustrated and neatly got-up, even at some sacrifice to myself. Unfortunately, the whole of the illustrations used at the lectures have had to be got out afresh; for though the diagrams were elaborately finished, their colours, together with their arrangement, prevented

them from being photographed or successfully treated in any way for publication.

As many desired that the discussion which followed the lectures should be published with them, I have appended it, as far as I have been able to collect it from the reports which appeared in the papers, having made myself but few notes of the discussion.

The lectures were presided over by Professor Corfield, M.A.; H. H. Collins, Esq., F.R.I.B.A.; W. R. E. Coles, Esq.; Rogers Field, Esq., B.A., C.E.; Professor Henry Robinson, M.A., C.E.; Noble Smith, Esq.; Ernest Turner, Esq., F.R.I.B.A.; and Lieut.-Colonel Thornycroft, J.P. Ernest Hart, Esq., Chairman of the National Health Society, &c., presided over the meeting on the night of the discussion.

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THE SCIENCE AND ART OF SANITARY PLUMBING.

LECTURE I.

INTRODUCTORY.

Unsanitary Plumbing—Force of Prejudices—Importance of Knowledge of Principles—Who should call themselves Plumbers?—Need of a School of Plumbing.

It is due to many here to-night, as well as to myself, that I should make one or two prefatory remarks before commencing my Lecture. I never aspired to address an audience such as I now see before me, for I do not set myself up as a lecturer. All that I intended, was to give a *quiet* address to plumbers. But, perhaps, I am now making a mistake, and you *are* ALL practical plumbers? I should, however, like to see your credentials, for I should then feel more at home. The ladies! well, I must think of them as a superior order of "mates."

Barnum, the American showman, once got together a great concourse of people to see some queer animal. The people were all formed into a ring or circus, and the poor little animal was set

in their midst, but the people were so disappointed that they demanded their money back again. Now, as many are likely to be disappointed to-night, there will be no money to return, but you will want compensation, no doubt. I beg, therefore, that you will indite your letters of complaint to the National Health Society, for *they* are responsible for your presence—*my* address is to working plumbers.

National Health Society.

When asked by the chairman of the National Health Society, Mr. Ernest Hart, to give a series of lectures on plumbing to plumbers, a doubt crossed my mind as to whether we should be able to get a good attendance of plumbers to hear them; for plumbers are, as a class, very independent, and difficult to draw out; they are still more difficult to turn, especially when they have a roll of lead on their shoulders.

Plumbers and Lectures.

Therefore, before deciding to deliver these lectures, I asked Mr. Hart to give me a week to think over the matter, and for enquiries to be made of the general London working plumbers, to hear whether they would be likely to attend in any force. I soon found that any doubt as to the interest plumbers would take in these lectures might be instantly removed, and the attendance*

* "The hall was greatly over-crowded, and the audience overflowed into the ante-rooms and even on to the staircase, so that many who attended were unable to hear the lecture."—*The Builder*, May 21, 1881.

Second Lecture:—"The hall was, as before, densely crowded, and great interest was manifested in the lecture."—*The Building News*, June 3, 1881.

to-night proves that the National Health Society was right in asking for such lectures to be delivered.

I do not underrate the difficulties of my position in addressing an audience of practical plumbers on the science of plumbing; for if it is difficult to get a joke into a Scotchman's head, it is even more difficult to get a theory into the heads of some plumbers; but I claim your indulgence.

Sanitary Plumbing.

For many years I have made sanitary plumbing my special study, and have written a book upon it; and as the joint-employer of the largest number of working plumbers of any plumbing house in the United Kingdom, I ask you to give me a patient hearing while laying down what I consider the true principles of sanitary plumbing and house drainage.

Theory and Practice.

I shall advance no theory which will not square with practice; and to carry conviction to every mind, or, so to speak, to make the new platform of plumbing thought strong enough for the plumbing world to stand upon, I shall prove my theories by practical experiments.

Working Plumbers.

In these lectures I am thinking and speaking chiefly of the general working plumber, the *hand-worker*, as I have elsewhere called him; but I have in my eye at the same time the *master* plumber, especially the small master plumber (who is both master and man), as I want what is said to be of service to all who call themselves plumbers.

Master Plumbers.

Plumbers and their Grand-fathers.

Unfortunately, some plumbers are difficult to move when once they have taken up a position;

and, judging from the principles on which many of them work, they must be occupying the positions taken up by their great-grandfathers about a century ago—schemes may come, and schemes may go, but they stand still for ever. For instance, I often come across service-boxes in drinking-water cisterns; badly ventilated soil-pipes; cistern-wastes connected with W.C. traps; waste-pipes from sinks, baths, and lavatories branched into soil-pipes; waste-pipes from W.C. safes connected with the soil-pipe or W.C. traps; connection with the drain everywhere, but *dis*connection nowhere. And this is not a word-picture of the plumbing in *old* houses only, for it is often seen in *new* houses, too, and I am ashamed to say it, both for the architect's sake and plumbers', in houses which have never been occupied.

Bad Practices.

Unsanitary Plumbing.

You will agree with me that plumbers who impose such unsanitary plumbing upon the public want waking up; they have been in "Sleepy-hollow" long enough, and should now be holloaed out.

Plumbers' prejudices.

Sanitarians are, no doubt, very hard upon plumbers, but rightly so, for continuing these old plumbing practices, now that a more excellent way has been laid down for them. "Men of light and leading" are moving along the new sanitary way, with their lamps well lit with truth, and yet the old-fashioned plumber in city, town, and village will not venture forth. There he stands, surrounded by his pets—D-traps and pan-closets—as full of bigo-

try as the many unventilated soil and waste-pipes he has fixed are full of bad air.

Professional Sanitarians.

But you say that plumbers do not take kindly to the new light offered them, because it comes from professional sanitarians. You say it is only artificial light—second-hand light—and that it flickers a good deal. I admit that in many cases it is only a *borrowed light*, and that there is not much heat in it. But there are good steady lights, held forth by sanitarians of experience, as well as the wandering lights which amateur sanitarians are fond of carrying about in their little lanterns.

More Light.

And as the cry should be for "more light," you should always be ready to receive it, whether it come from a rushlight, lantern-light, fanlight, or skylight, but the purer the better. Never extinguish a light, but try to distinguish yourself in the light.

Whenever you find a man who will not open his mind to receive knowledge, no matter from whom or whence it comes—and it often comes from quarters whence it is least expected—you find a man profoundly to be pitied. The flowers open their petals to receive light (and they will work their way through many obstacles, even through brick walls, to get it), but so unselfish are they that by a little chemistry of their own they turn light and air into sweet perfume, and so give back again all they receive. And shall Man, the thinker, the great reciprocator, shut up his mind, and cease to

carry on commerce with mind? That may do for mummies, it will not do for living men.

Men differ.

But all men are not alike. Some men are like *cistern-heads*, they hold nothing; for as fast as you put anything into them, it runs out again. And there are men like *solder-pots*, which are soon filled; and then, when they are filled, you can get nothing more into them. But, fortunately for the world's progress, other men are like store-cisterns, which are ever ready to fill anybody's cup, and which never get empty, for they are supplied by a ram fed by an ever-running brooklet, or a never-failing spring.

Man's Duty.

Now I hold it to be the duty of every man to do his utmost to make himself a thorough master of his trade or profession, not only for his own good, but for the good of his time, and for the good of his country; and blessed is that man who counts this not only his duty but his privilege. He may be only a poor working plumber, but if in his life he has done his best, his life will not have been wasted, though his name go with him into the grave,

"Unwept, unhonoured, and unsung."

It is not so much *what* a man does that makes his life grand, as *how* he does it.

British Workman.

The British workman is not a general favourite with the public, and the plumber is no exception; for everybody takes the liberty of having a fling at him. Shakespeare—who saw into men and things with the eyes of a Seer—saw a weakness of the

plumber in his day, and struck him, as he used to strike, hard. But Bacon saw the better side of him, for he speaks of the "goodly leads" laid by the plumber on the "three-storied tower."

Plumbers and Tinkers.

There are plumbers *and* plumbers; and as it would be unfair to judge of the medical faculty by quacks, so would it be equally unfair to judge of plumbers by tinkers.

Jacks of all Trades.

Men who write on their signboards, "Plumber, Painter, Glazier, Decorator, Paper-hanger, Gas-fitter, Bell-hanger, Copper-smith, and Tin-plate-worker," are not likely to be skilled plumbers, but they are very likely to be "Jacks of all trades and masters of none."

I am not exaggerating when I say that scores of such signboards can be seen throughout Great Britain, with the additional trades, in some cases, of "Builder, Hot-water engineer," and sometimes "Undertaker"—the undertaking part of so many trades must be unquestionable. Some such boards are to be seen within six miles of this spot. Men write a long list of trades on their business-cards, and then wind up with the words "Sanitary Engineer." And as a proof of their great sanitary knowledge, they call in an engraver, and get a Pan closet, with a D-trap and service-box supply arrangement, illustrated in the margin of the card, as a sort of badge; and then, to remove all doubt as to their ability, they write across the card in *italics*, "Sanitary work carried out on the newest principles." We have had several such cards sent to our house

of business :—An enlarged copy of this card—and a sample of many such—was shown on the wall, as actually received by us in the early part of this year. On the left-hand side is a wood-cut of a *Pan* closet seen in section, fitted with D-trap and *elbow* soil-pipe, and supplied by a service-box fixed in a drinking-water cistern! The inscription runs—

X. Y. Z.,

BUILDER, PLUMBER, PAINTER,

Glazier, Carpenter,

RANGE AND STOVE MAKER,

Hot-Water Engineer,

PUMP MAKER AND SANITARY ENGINEER.

WATER-CLOSETS FIXED ON THE *NEWEST* PRINCIPLES.

WRITING, GRAINING, MARBLING.

Fountains Erected.

Master of Arts.

What must be the age of such a man? Suppose we say so many years for each trade—but it will take too long to reckon up, so let us put him down as *very ancient*, and, though Oxford or Cambridge know him not, he is entitled to the degree of Master of Arts. I recommend the public to look *twice* at such sign-boards before entering under them once to get *sanitary* work done. They should be treated as *warning-boards*, that "he may run who readeth."

I know there would be great difficulties in separating each individual trade just mentioned, especially in small towns and villages, where it is almost necessary for men to be what are called

"three-branch hands" to get a living; but I contend that no man should be allowed to call himself a plumber, unless he understands the art of plumbing. Further, I would insist upon every man being *licensed* before being allowed to carry on the practice of sanitary plumbing, or to write "Sanitary Plumber" or "Sanitary Engineer" on his sign-board or door-plate. And before he would obtain such a license, he should be made to pass an examination in the Science and Art of Plumbing before fully authorised and qualified examiners.

Licensed Plumbers.

There is no trade the full knowledge of which by the craftsman is so important for the general health of the community. The ever-increasing army of earnest and able medical men that are labouring so self-sacrificingly, and therefore so nobly, under the modern banner of "Preventive Medicine," will labour in vain if their efforts are not seconded by the plumber. The medical man is fully alive now to the value of house sanitation; and when he has reason to suppose that his patient is suffering from a complaint attributable to bad drainage, he at once calls upon the head of the family to "set his house in order," and the plumber should be equal to the occasion.

Medical Men and House Sanitation.

A stinking water-closet; a non-cleansing sink or closet trap; a badly-ventilated soil-pipe or waste-pipe; a sewer ventilating itself into the house-drain; a drain ventilating itself into the house—through a surface-trap, bell-trap, or any

Bad Plumbing.

other kind of trap or defective piping; a drinking-water cistern badly placed, or in direct communication with a W.C. through a service-box supply arrangement, is quite sufficient to make a house unfit for occupation.

Anybody a "Sanitary" Plumber.

Now, when *anybody* is allowed to set up as a "sanitary plumber" regardless of any qualification for it (except a few D-traps and pan-closets, &c., in the window for the master plumber, and a large pair of corduroy trousers for the journeyman, with a little knowledge of joint-wiping), how are the public to know the skilled and qualified plumber from the unskilled and unqualified? It is easy to say "Codlin is your friend;" easy to write "Plumber" or "Sanitary Plumber," or "Sanitary Engineer" on a sign-board or door-plate, but *is* the man what he professes to be? The important question is—How am I, a stranger to plumbers and plumbing, to know that the man who calls himself a plumber is competent to carry out the plumbing I want done in my house on sound sanitary principles?

Some people will say "things right themselves, as boats when capsized." But do they? At any rate, if they do, it is generally after they have done a deal of mischief. Others will say, "householders will soon find out when they have employed the wrong man." Alas, poor victims, yes! But not before they are in the occupation of their houses, and it will then be too late in many cases, for they will have laid out all the money they can spare in

Householders, victims.

the alterations of their houses, and in beautifying them—for some people have a bad habit of spending right up to the hilt of their means; and if they have any money left they want that for a nobler purpose—namely, for educating their families. They know that the sanitary arrangements are defective, for they meet with signs of bad drainage in many parts of their habitations, and when they go into their water-closets it is like going into huge smelling-bottles. But they have paid for the work to be done properly *once*, and rather than pay for it *again* they prefer to run some risk, and ill-health and sickness are often the consequence.

The misfortune is, that if the dissatisfied householder send for the plumber who did the work, to come and explain the cause of certain bad smells in his house, he would not get much help from him; for when he came he would remember that the plumbing had been done by him to the best of his ability. If he went into the water-closets he would only find a "little smell," but his well-seasoned nose always finds such smells in W.C.'s, and he would only find what he expected, a fusty closet smell, as of dried excrement upon a large unwashed and uncleansed surface. He would admit that it would be rather sickly to live in such W.C.'s, but as one is only in such places for a short time daily, he would think it does not so much matter. He would forget that such stinking closets, when they exist, breathe out their filthy odour into the house day and night. And as he would most likely

be totally oblivious of the fact that W.C.'s *could be fixed which would not be in anyway offensive*, he would take his departure, in peace with his own mind, to perpetrate in other houses the same evil deeds.

The Public and the Plumber.

This is most unsatisfactory, both for the public and the plumber. The public have a right to be guaranteed against such unsanitary plumbing when they call in a plumber, and if plumbers were compelled by Government to have a licence before being allowed to carry on their business, no such stinking water-closets would be fixed, no such tinkering plumbing would be done, and the health of this great city, the health of our towns, the health of our hotels, the health of our sea-side lodging-houses, would be generally improved.

Unsanitary Closets in Hotels.

I am often travelling in various parts of the country, and the first thing I do when I have to stay a night at any hotel, is to see that my bedroom is well removed from any water-closet or sink. I remember staying a night, a year or two ago, in one of the best hotels in one of our most ancient cities. I could not get off to sleep; my mind was at home, but my sense of smell was with me in the bed. I sniffed about a bit—as a dog does when it turns over a turnip leaf where a rabbit has been sitting nibbling at the turnip a little while before—and sniffed a water-closet smell. I could not understand this, as, with my usual precaution, I had looked to see that no water-closet was near. A little later on in the night, the odour became more

pronounced, and I came to the conclusion that it came from an old pan-closet. In the morning I found, sure enough, a water-closet, and I noticed, too, that it was a *pan*-closet. "Hast thou found me, O mine enemy?" I said, as I banged-to the door, and traced how the smell had passed to my room. It had travelled behind the skirting of the W.C. and the skirting of an empty room into my bedroom ; and having to stay at this hotel another night, I shifted my quarters.

I rarely come across a *perfect* water-closet, from my point of view, in any of the best old hotels. On the contrary, I am frequently coming across very imperfect ones, and I pay my visits to such places with great reluctance, for I cannot leave my nose outside, and, being a non-smoker, I cannot set up a counter odour in the shape of a cigar.

Sanitary arrangements on the Continent.

The old saying that "They do these things better on the Continent," is, I fancy, wearing out in more things than one. If it ever referred to plumbing and drainage, the Continental peoples must have very much degenerated, for there is hardly a W.C. fit for a decent person to use between Paris and the Rhine. I have sought for a wholesome W.C., I was going to say with tears.

In some of the grandest hotels, surrounded by the fairest sights earth can afford, there are to be found some of the filthiest W.C.'s in the world, places which make you long for a quiet nook away from the haunts of men.

The utter absence of good sanitary arrange-

ments must be a great drawback to the enjoyment of English people when travelling abroad. And while such water-closet accommodation is allowed to exist as now exists, a great disgrace attaches itself to the Governments of such countries. But I am forgetting I am speaking to English plumbers; and we must not throw stones, for we live in glass houses ourselves.

Sanitary Water-closets.

I know, and some of you know well enough, that there is no difficulty in fixing a water-closet which shall send out no bad odour at all. Nay, more, that it is not only possible but easy to fix such an apparatus—a water-closet which shall keep as clean and sweet as a bedroom toilet basin. But I know of no means whereby a stranger coming to London, or going to any city or town in Great Britain, could feel *certain* that he would get such a sweet closet fixed in his house, if he wanted it. The chances are, that in the present state of the trade he would not, for he would have no means of distinguishing between the sanitary and the tinkering plumber, and most likely would call in the wrong man. This, to my mind, is a very lamentable state of things.

Education.

But some will say, What would you do? Would you annihilate *un*sanitary plumbers? No! I do not believe in annihilation; I believe in progression. I would *educate* them in the theoretical knowledge of their trade, and *perfect* them in its practical application. I would rub them up, as they do their irons when they take them out of the

fire—to get the scales off and to brighten them up for better use.

We have Schools of Art in every quarter of London, where willing students study painting, drawing, &c. Heaven forbid that I should say one word against such institutions. I mention them for contrast, for what have paintings to do with the *health* of the public? They may have a great deal to do with the moral tone of society, for in beholding the "true and the beautiful," the mind ought to be elevated, and the man who hath no eye for the beautiful is as bad as the man who hath "no music in his soul." But the *health* of our homes does often depend upon *how* the plumbing work is done in them. Schools of Art.

It is monstrous that here in London, where I believe plumbers are more skilled in their work than in any other city in the world, there is no school for the study and practice of plumbing: no Sanitary Science Hall, where plumbers can pass examinations in the art and science of their trade, and receive diplomas authorising them to pursue the practice of plumbers; no place where journeymen can meet to learn the theory of their craft. I believe such a school would do immense good in spreading the theoretical knowledge (the why and wherefore) of plumbing among plumbers, who now only care for the practical knowledge of their trade. And the public would reap the benefit, in having happier lives, lives more free from petty Sanitary Science Hall.

annoyances, and healthier homes in which their lives would be passed.

Schools of Plumbing.

Though the chief object of such a school should be to teach the principles of sanitary plumbing to plumbers, it should not be limited to this, but should impart a practical knowledge or dexterity to learners in the trade.

Class-rooms.

Class-rooms should be set apart for young plumbers to improve themselves in the practical knowledge of plumbing, such as joint-wiping, pipe-bending, bossing, &c. And as this would involve some extra cost to the institution, in firing and in the use and waste of materials, the students should contribute accordingly.

Models.

Good models of plumbing should be placed where the student, or "improver" (as he is generally called by the trade) could examine and study them, and models of all kinds of sanitary fittings should be kept in the institution for easy reference.

Teachers.

Foremen and journeymen plumbers well advanced both in the practical and theoretical knowledge of plumbing could become teachers, and form classes, which could be examined from time to time by a committee elected for such purposes, and rewards could be given according to merit.

Lectures.

Lectures could be given illustrating and explaining the newest principles in sanitary plumbing, and old errors could be pointed out and condemned.

Plumbers meeting thus together could compare experiences, and correct wrong impressions and

practices ; and in this way the newest light in plumbing practice would make its way with rapidity, to the benefit of all concerned.

Certificates of Merit.

But the grand thing in connection with such a School, or Sanitary Science Hall, would be that CERTIFICATES OF MERIT could be given to those who qualified themselves to receive it, and the public could be *assured*, when they called in the holders of such certificates, that they would be employing competent men.

Legacy to Found a School.

I do not want anybody to die. But if some rich person, who wanted to do a noble deed, would leave a sufficient legacy to found such a School or Institute as we have just been considering, and if he would give an additional sum to be appropriated in prize-moneys, to be given away yearly to *young plumbers* who passed certain examinations in the *practical* knowledge of their trade, and to *journeymen* plumbers who passed certain other examinations in the theory as well as the practice of plumbing, an immense impetus would be given to plumbers to perfect themselves in their craft, and the public would be the gainers.

City Guild of Plumbers.

I believe the City Guild of Plumbers is at last going to stir itself to do something towards improving the craft.* But though this Guild received its

* By aiding the City and Guilds of London Institute for the advancement of Technical Education, and other ways. At the Technological Examination of this Institute, in 1881, eighteen persons passed examinations in *Plumbers' work, &c.*, three of whom took prizes—one (my foreman, James W. Clarke) £5 and a

Charter in 1611, I have yet to learn that it has done anything to educate plumbers. Has it helped any one, any of the London plumbers of to-day? Has it done anything through all these centuries to encourage young plumbers in the study of the art and science of their craft? History is silent on this question, and I will be silent too.

Plumbers' Societies.

There are your own societies, your unions, what have they done to advance the *technical* knowledge of plumbing? If they have in any way bettered your positions, acknowledge the good they have done. But do your societies insist upon each member being thoroughly skilled in the art of plumbing? Or, if after he has been elected a member, he is found to be a *muff*, is he struck off the roll? I trow not; at any rate, the fact that a man is a society man is no *guarantee* that he is a sober, industrious, and skilled artisan, and this to my mind is the weak joint in the vulnerable armour of union societies.

Men are so different.

Men are so different, you cannot level them like water. If all men were cast in the same mould, like the rain-water heads of a building, they might have the same treatment; but as they are as various as the chimney-pots of London, they must have various treatment. While one man is cocking his gun, another will have his bird down; while one plumber

bronze medal, one £3 and a bronze medal, and one £2 and a bronze medal. Plumbers who wish to benefit themselves, and to test their knowledge, should apply to the Secretary of the City and Guilds of London Institute, Gresham College, London, for a programme.

is lighting his fire, another will have made his joint; while one is looking at a trap, another will have fixed it; while one general is riding hither and thither on the battle-field, another will take the whole surroundings in at a glance, and march straight to victory.

Natural World.

It is just the same in the natural world. Come with me to the cliffs of the sea, and watch the wild waves marching to the shore. How they differ in size, in height, in sweep! Linger here awhile, until the fall of night, and then lift your eyes, and behold the night-lights of the sky, and see how they differ; and as one star differeth from another star in glory, so does man from man here and everywhere. Or go to the mountains, and let your eye run up the heights; peak after peak rising higher and higher in the land of eternal snow, but head and shoulders above them all stands Mont Blanc, in snowy serenity, a king among mountains.

Look to yourselves.

So do not look to union societies, to City Guilds, or committees of men, but look to *yourselves*, and put forth every effort, and strain every nerve, to become intelligent men, skilled in every section of your trade.

The Plumber sinned against.

The plumber is often more sinned against than sinning. His work, unfortunately, is chiefly out of sight, and though he has done the work well, it is rarely appreciated.

There is no trade which the public know so little of; and, knowing little or nothing about it, they

care but little. Even architects, who are expected to know everything in a building, from the front door-key to the lightning-conductor (though how they are to do it is the puzzle of puzzles), know but little, as a rule, of plumbing. They can give wonderful detail drawings of everything except plumbing, and when they attempt this they generally fail.

Ignorance of Plumbing.

Plumbing out of sight.

One reason why the public take so little interest in plumbing, is that the work is chiefly out of sight, and when you cannot appeal to the eye, you miss a very valuable organ. Other trades leave their work to be seem, except gas-fitting, and a light is generally coming from that. The work of the mason, joiner, painter, glazier, plasterer, bricklayer, paper-hanger, decorator, upholsterer, &c., speaks for itself; but the work of the plumber—the most important trade of all, as far as the health of the house is concerned—is out of sight, to a very large extent at any rate.

Praise of Women.

Again, it is not a trade to call forth the praise of *women*. And if, as the author of "Endymion" thinks, women make men, there is little hope for the plumber, for the trade is outside of their influence to a great extent. If we wanted to give pleasure to a lady-friend, we should not buy her a lead-trap, or a bath—except we wanted to get into hot water—or any other piece of plumbing. We should patronise the artist, the jeweller, the publisher, the carriage-manufacturer, but never the poor plumber.

The gentle sex exerts a large influence upon other trades, and it is not too much to say that where one lady asks her lord to spend a pound on plumbing, a hundred ask for thousands to be spent on the other trades, and get it spent too.

Large Bill and little to show.

The misfortune is that when the plumber or sanitary engineer is called in, he may spend a good sum of money, and leave little behind to show for it. He may have reconstructed the whole of the plumbing, and laid down an entirely new system of drainage, and yet the only things to show for this may be a *pigeon-house* cowl on the roof, and a *bill* in the library. It is true that in many parts of the house where the air was laden with foul stinks, pure air now circulates, but you cannot see air, and many people cannot smell it when it is charged with soil-pipe or pan-closet odour; for "noses have they, but they smell not." Now a few pounds spent in paper-hanging and painting, turn a dingy old house almost into a new one.

Disadvantages.

Plumbers labour under other disadvantages; and if we look at them we see why plumbers have not advanced, as they ought, in the theoretical knowledge of their trade.

Faulty Specifications.

1. They work one day under a specification drawn up by an architect who knows little or nothing of plumbing. The body part of the specification has been doing duty for a long time, and for many a house; and now, with but slight alterations, it is doing duty again. The architect con-

centrates his powers upon "elevation"—but not the elevation of the plumber; for it is the façade of the building that will make his reputation, and not the plumbing.

They work another day under the specification of another architect, who goes in for good strong plumbing. Everything must be made of the best material; but, belonging to the old school, he specifies very large soil-pipes and drains, and very small air-pipes, and thus "extremes meet" with a vengeance. He insists upon D-traps and (their outgrowths) pan-closets, for "they do not get out of order like your new-fangled things." It is useless for the plumber to explain that these *un*sanitary fittings have an odour of their own, after they have been used a week or two, different from a rose or a lily though quite as pronounced, for the architect insists upon the "specification being followed."

Another day the plumber works under another architect, and is obliged to put on his glasses (and perhaps take a glass or two as well) for he can't believe his eyes. What, fix a tier of closets on one stack of soil-pipes *without* traps? Yes! for so reads the specification; and this architect, or amateur sanitarian, is not going to be influenced by anybody's experience or judgment in this matter; for has he not rubbed shoulders with some great sanitarian? Lavatories, baths, sinks, and water-closets are then fixed without traps; the waste from the former doing double duty, namely,

that of taking off foul discharges and ventilating the house, and the latter, the untrapped water-closets, only waiting for a leaky valve or a piece of hard substance under it to do the same. I am not referring here to Mr. Norman Shaw's principle, for, though he may allow *waste-pipes* to be fixed as just described, he does not fix a *tier* of trapless closets upon *one* stack of soil-pipe. Is it any wonder that the plumbers should be at sixes and sevens, when architects are playing "ducks and drakes" with their clients' money in the way I have been describing? Thank the stars that shine out in the darkest nights, there are architects who take an immense deal of trouble to have the sanitary arrangements in their buildings perfect, and, if they do not clearly understand sanitary plumbing themselves, they trust to those who do—not throwing away their own judgment however, nor picking up loose ideas in the streets.

Anybody employs Plumbers.

2. Another disadvantage to the trade is that anybody employs journeymen plumbers. Builders, Upholsterers, Cabinetmakers, and, I am told, now Drapers carry out plumbing jobs. Now, it requires a builder of large operations to keep a good, competent foreman of plumbers, and a *permanent* staff of journeymen always going; but, unless this is done, the work done by such a builder will not be of a high class, and such work will be injurious to the trade. Well, if it is difficult for large building firms to keep plumbers on *constantly*, how much more must it be for the other trades just

mentioned, and for small builders? The fact is, the men in such places are taken on just when they are wanted, and discharged directly their work is done. There is no *home-feeling* encouraged in the men, and no great interest taken in their work; for the chances are that their master, if he knows any trade at all, is a joiner, and the manager or foreman a bricklayer or stonemason, but most likely a carpenter too—for carpenters generally make the best foremen. Now, is it not reasonable to suppose that in such houses of business the master and manager will take their greatest interest in the trade with which they are best acquainted rather than in sanitary plumbing, which they know little or nothing about? And, as to the men themselves, their best efforts are not likely to be called forth where their work is but little appreciated, and where directly they have finished their job they have finished with that master, for he has nothing more for them to do. But, where men know that directly one job is done another awaits them, and that they will only be discharged for indolence, bad workmanship, or some misdeed, an incentive is given them to do their best. And not only that, for, if they did their work badly, when they are in a constant place they could be called upon at any time to explain, and such complaints would not tell in their favour, and this they would soon find out.

Plumbers' Shops and Apprentices.

3. But there are other influences at work against the growth of plumbing knowledge. Men seldom

learn, or only half learn, the trade of plumber. I believe it is not only difficult, but impossible, for young men—apprenticed or not—to learn the art of plumbing in nine-tenths of the so-called plumbers' shops of the present day. There is so little experience for them in such places; and in many of these shops painting and glazing are the staple trade, and plumbing is the accessory. Young men and apprentices, not only do not get any *practice* in good plumbing, they never *see* it done. I know we must have "small" men, or who should we have to go into our small cisterns? but small shops are not the places for youths to be apprenticed in. I never knew a man (and I have known hundreds of young men from all parts of the country), who came from any shops in our country towns, even though he had worked in them for a year or two beyond his apprenticeship, capable of doing a plumbing job as we have it done in London. I believe "three-branch" country shops to be good drilling places for two or three years, as they open a youth's eyes and make him handy; but it is a monstrous waste of time, to my mind, for a young man, who intends to perfect himself in plumbing, to spend five, six, seven and eight years in a country shop, as many do, before coming to London. For come when he may, he is certain to have to work as a mate, *i.e.*, a plumber's labourer, for a year or two. At any rate, he would if he came to 21, Newcastle Street.

I have looked at plumbing work, done by

Country and Foreign Plumbers.

plumbers in our chief towns in England, Scotland, Ireland, and Wales, as well as in France, Germany, Belgium, and Switzerland—and I generally keep my eyes open, and I think I should see a piece of plumbers' work as sportsmen see game, when nothing is visible to the eye of a stranger—but I never saw in any of these places such *finished* plumbing, such well-made bends, such good bossing, as I am constantly seeing in London, or in places where the London plumber has done the work.

London Plumbers.

Now though the average London plumber is much in advance of plumbers generally in *practical* skill, and in theoretical knowledge too, yet his knowledge of house sanitation is very deficient. However, there are a goodly number who know a good deal about sanitary plumbing and house sanitation; and I know further that such men would pass a stiff examination in the science as well as in the art of their trade. They would astonish many of our experienced sanitarians by the knowledge they possess on this subject, and they would be able to enlighten them on many points of detail.

Object of these Lectures.

To increase this knowledge, and to stimulate plumbers everywhere to perfect themselves in the knowledge and application of their trade is the main object of this course of lectures. I hope by practical experiments, and carefully prepared illustrations, to convince the oldest fashioned plumber among you of the advantages of the new way of sanitary plumbing, over that of the old or unsanitary way.

I will not waste time by arguing with the man who forms so poor a conception of his duty as to say he has nothing to do with the *theory* of his trade, and who thinks that because he has learnt the practice of it he has learnt enough:—

> "Breathes there the man with soul so dead
> Who never to himself hath said"

"I will do what I can to learn my trade thoroughly." Where is the eye that does not take delight in the beauty and changing tints of the leafage of fruit-trees? But the practical part of such trees is to bear fruit.

Government Schools for Soldiers, but no Schools for Plumbers.

We have Government training-schools for teaching soldiers how to put lead bullets into men with the ease with which plumbers put lead wedges into the joints of brickwork to secure lead flashings. We have public jails all over the country to keep men who are injurious to society; but we have no schools, no public institutions where young plumbers can spend their evenings in perfecting themselves in the knowledge of their craft, that they may do some good in the world.

Nationa Health Society.

The motto of the National Health Society, through whose auspices we are here to-night, is "Prevention is better than cure." How much sickness, how much bad health in homes, in towns, in cities would such training-schools for plumbers be the means of preventing? Plumbers little know what mischief is caused by their unsanitary plumbing, for it might be said of them, as was said

of a far worse crime "I wot that through ignorance" they do it.

Well, as no such plumbing-schools are provided, you must start one yourselves; and, if you put your heads and purses together, you will have no difficulty in making such a school in London self-supporting. I shall have great pleasure in presenting good models of plumbing work whenever such a school is started.

Public to be congratulated.

The public are to be congratulated that architects are taking up this subject of house sanitation, for it is as much their birth-right as the plumbers'. In new houses they are masters of the position—for they hold the purse-strings—and if they only insist upon having the plumbing and drainage carried out on sound sanitary principles in all the new houses they build, great good will be done. There is a shaking of dry bones, and both architects and plumbers, here and there throughout the country, are clothing themselves with sanitary knowledge. Only recently there have been some important discussions on this subject at the Royal Institute of British Architects, and elsewhere, and if sanitary knowledge should find a congenial atmosphere anywhere it should be in such institutions.

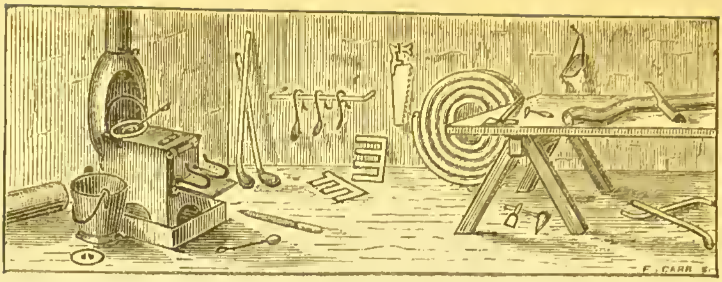
Architects and Plumbers.

I believe that if architects and plumbers throughout Great Britain seriously took up this question, there would not be in a few years' time a *new* house between John-o'-Groats and Land's End in

such an unsanitary state as two-thirds of the houses are to-day in Belgravia.

Master-plumbers and journeymen-plumbers! rise up to the needs of the times, and march in the van of progress!

I may have wearied you with this lengthy introduction, but plumbers will not complain. They know well enough that it often takes longer to prepare the ends of pipes for good connection than it does to make the joint. As I have now come to the subject of *joints*, but as these joints are not for the supper-table, I will defer what has to be said on them until we meet again, especially as the "metal" is now somewhat cold.



LECTURE II.

JOINTS AND PIPE BENDING.

Wiped Soldered Joints : Underhand, Upright, Overcast, Branch, Block, Flange, Taft. Copper-bit Joints : Float or Flow, Ribbon, and Ribbed, or Overcast, Astragal Joints, Blow-pipe Joints. Pipe Bending : Elbows, Bends, &c. Lead—Pipes —Solder—Alloys and their Melting-heats—Fire-places— Blowing-lamps—Lead-burning.

Everything made by Machinery.

ALMOST anything and everything—from a German-sausage to a Swiss-chalet—can now be made by machinery ; the clothes on your back, the shoes on your feet, the watch in your pocket. By its aid wood, stone, or iron can be formed into shapes of beauty, and straight or circular mouldings cut with mathematical precision. The materials of a building can not only be cut into shape and be hoisted by machinery, but they can be taken round to the very spot where they are wanted by it. The inventive genius of man is so great that he has annihilated space, and brought the country-house alongside the town-warehouse, for the merchant can sit in his counting-house and talk with his family in the country, though the distance between the two places may be greater than that pierced by the eye of an Indian or a pigeon. Nay, the living voice

Genius of Man.

may be caught and sent to a friend, or a child travelling in a distant land, and the music of its notes may be heard when the mouth which uttered them may be silent in the grave.

The United States of America may be called the *forcing-house* of inventive genius. The fact is, "wandering-stars" from other countries have been collecting in this part for generations past: And as the "stars" joined one another in matrimonial united states (came into contact with each other), the "sparks" flying off from them have been burning with a white heat of inventive force. But though the Americans have invented machines to America.

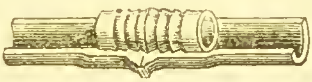


Fig. 1.—Welded Joint.

help everybody as well as the plumber, they have not yet invented an apparatus for making *wiped* soldered joints. They have, however, invented a machine for uniting lead pipes of small diameter together by what are called "welded" joints; but this mode of union is inferior to a wiped soldered joint. Two such machine-made welded joints were made on $\frac{3}{4}$-inch pipes in my presence in the space of a few minutes, including the preparation of the ends of the pipes for such connections. Fig. 1 illustrates one of the joints.

JOINT-MAKING may be called the *Alpha and Omega* of the plumber. It is, so to speak, the staircase which takes him to the various rooms in the

house of plumbing-knowledge. To leave joints out of plumbing, would be to leave Hamlet out of the play of "Hamlet."

Joint-making difficult.

I daresay joint-wiping to the majority here to-night is as easy as "shelling peas," but to the beginner it is no easy matter. Nay, as you who have burnt your fingers over it know, it is very difficult, so difficult that no man without considerable practice can accomplish it. And some plumbers, though they make joints daily, never learn how to make a perfect joint. There is always something the matter with their joints! They are "gouty," or "potatoey," too light or too heavy, too dumpy or too elongated. And though they are not like the world, flat at the poles, they are flat at the sides. They are in no way symmetrical, and their want of rotundity is very observable.

Will the good joint-wipers here to-night—the men who have no difficulty in making wiped soldered joints as true as if they were turned in a lathe—bear with me, while, for the sake of the less initiated, I enter into the elements of joint-wiping and joint-making, which may possibly interest even them.

Preparing Pipe-ends.

In preparing the ends of the pipes to be connected together, either in a vertical or horizontal position, see that no burr is left on the inner edge of the male pipe. In rasping off the outer edge of this pipe, a burr is formed on the inner edge, and if this is not taken off with a shave-hook or pocket-knife, and smoothed, the roughness would be liable

to catch any hair or such-like thing passing through, in a soil or waste pipe. Well open the end of the outer pipe to allow the inner pipe to enter about $\frac{1}{4}$-in. or $\frac{3}{8}$-in., without contracting it in any way (as shown at A, Fig. 2). Rasp off the outer edge of the female pipe, to get a greater thickness of solder upon the joint without increasing its external size.

"Soiling."

In "soiling" the ends of the pipes, "soil" over at the same time, or better still, after the ends have been shaved, the *inside* of the *inner* pipe, *i.e.* the male end, to prevent the solder running and adhering to the edge brightened by scraping off the burr.

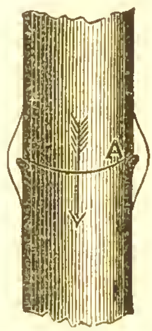


Fig. 2.
Section.

Shaving-line.

To get a true ring round a pipe of *large* diameter for the shaving-line, put the blade part of a saw, or a piece of planed wood, against the end of the pipes, and take a pair of compasses (opened out the width of the shaving required) and describe a line round the pipe with the point of one of the legs, resting the other leg against the saw-blade as a guide: you will in this way get a truer shaving-line than if you described the line without the aid of the saw-blade or flat surface board at the end of the pipe, and you will save time as well—of course, in small pipes no such guide is wanted. In *shaving* the pipe, be careful not to *dig* the shave-hook down into the lead, especially at the *outer edges*,

Pipe-shaving.

as it would weaken the pipe where there would be no thickness of solder to strengthen it again, for in wiping the joint the solder is often wiped away at the outer edges, and no thickness of solder is left upon the outer edges of the jointing. All that is wanted is to take off the dulness of the lead, for the solder to readily tin upon it.

Ends tinned.

When joints are to be made to funnel pipes *in situ*, (in chases where the back part of the pipes cannot be seen), the pipes should be tinned upon the bench before they are put in their places, to prevent any foreign matter, as brick-dust, mortar, &c., getting between the solder and the pipe, and also to ensure the end of each pipe being well tinned all over. When the ends of such pipes are only shaved (and greased) on the bench, and not tinned as well, in carrying the pipe—with, say, its tacks and W.C. trap upon it—to its position, the grease may get scraped off in places by the end of the pipe being knocked against a wall, or dragged on the floor, and then in wiping the joint the solder may not *tin* itself upon the damaged places.

Ends against the stream.

In life it is often the manlier way to go *against* the stream, but in jointing, especially in all soil, waste, or drain pipes, the ends of the inner pipe should always go *with* the stream, as shown at A and by the arrow, Fig. 2, *i.e.*, the *edge* of the *inner* pipe, the male end of the jointing, should never be fixed against the current in waste-carrying pipes,

for it would form a ledge for dirt and filth to accumulate upon.

For the benefit of the unskilled, I should like to say a word or two on joint-making; and first, as to the solder. I need not say anything about the proportions of lead and tin, for solder is generally bought ready for use.*

Solder for upright, branch, and flange joints, and for sink and cistern wiping, wants to be a little finer than that for underhand joints. When the solder is too rich for making underhand joints, put a little *soft* pig lead into it, but do not put any lead pipe or new cuttings into it, for such lead may not be pure. When you have made the solder right for easy use, keep this solder-pot *in large jobs* solely for making underhand joints, to avoid any further bother or loss of time. Get another solder-pot for general work, and, as the tin wastes by constant heating, supply the solder-pot for making underhand joints from the richer solder-pot, and feed the richer pot from the new "casts" of solder —in small jobs it may not be worth the trouble of this. Plumbers' Solder.

"Waste not, want not" would be a good motto to put round every solder-pot, and plumbers will do well to remember that though the solder may "Waste not, want not."

* I suppose that not one journeyman plumber in a hundred, in London, makes solder. To make good plumbers' solder, put sixty-five per cent. of soft pig lead to thirty-five per cent. of (Truro) tin, but as tin varies a little in quality, at times it may require more or less than the quantity given:—Two parts of lead and one of tin is the general way of calculating plumbers' solder (see p. 72).

not cost the user anything, it really does cost money, and should never be wasted by putting more solder upon the joint than good work requires, or by not carefully picking up the splashed pieces near where the joint has been made, or by over-heating—or by keeping it always over the fire; for it is not necessary to keep the solder-pot always "boiling"—that may do for the cook's pot, but it will not pay for the plumber's.

Heating Solder.

In heating the solder over a coal or coke fire, keep a cover, say a piece of board, over the pot to keep the heat from flying off; but if the solder is being heated over a wood fire, put a large ladle over the top of the solder-pot with its mouth downwards, allowing it to sail over the top a little so as to catch the flame and turn it inside to assist in heating the solder, but do not allow too fierce a flame to fall upon the solder to eat the tin away, for the tin rises to the surface.

Time is money, therefore get the solder heated as expeditiously as you can, and never over-heat it —for in so doing you cause the solder to deteriorate, and if pockets never have too much "tin" in them, solder-pots are often like them in this matter. You can tell the right heat by taking out a ladleful, and holding it near your face, or by passing the back part of the hand over it. Or a piece of wood is a good indicator, for if by dipping a stick into the solder the stick smokes, it is ready for use.

Under-handjoints.

UNDERHAND JOINTS.—In making an under-

hand joint, first pour the molten metal on the soiled parts of the pipes to get the pipes well-warmed. Then pour a dribbling stream upon the shaved parts of the pipes to be united, and well tin them by pulling the solder round and round with the solder-cloth. Keep on pouring out the metal, and "let it flow" in one continuous stream round and round on the outer edges of the tinning, working at the same time the solder towards the centre part of the joint, and bringing the solder from the bottom of the jointing to the top. After manipulating it in this way, for a minute, and directly it is of one consistency, and in a "teachable" mood, wipe the joint, coaxing the solder round and round to get the joint symmetrical.

If you prefer to use an iron, see that it is well cleaned, and just red-hot before using; then, having a nice body of solder on the joint which is to be, rub the hot iron round and round it, and take it all off on the cloth. Rub the hot iron upon the solder, and work it up into a nice consistency upon the cloth, forming it all the while into the shape somewhat of a sausage-roll, then quickly place the centre part of the solder against the underside of the pipes, at the centre of the jointing, and turn up the outer half on the off-side, bringing the hand back quickly to turn up the other half on the near side. When this is done, wipe the joint with all the dexterity you can command. Of course this refers to underhand joints upon *small* pipes. In making an underhand joint upon *large* pipes, there will be no diffi-

Joints upon large Pipes.

culty in getting the solder to stay upon the upper sides of the pipes, the difficulty will be in getting it to adhere to the under sides, where it has a tendency to drop off in lumps directly the pipes get hot. In making such a joint, keep moving the solder round and round the pipes, pouring the metal upon the cloth as well as upon the pipes, to convey the solder to the *underside* of the joint in a molten state; this should be alternately done on near and off sides of the pipes during the process of making the joint, and the solder forming round the under side of the joint should be brought round upon the upper side. When a good bulb of solder is formed upon the pipes, the ladle should give place to the iron, and the joint should be wiped as expeditiously as possible, remembering that one secret of success in wiping such a joint is to keep the cloth following close to the iron. The outer edges, to make a nice clean joint, as shown in Fig. 3, must be kept well heated with the iron. I have here an underhand joint, wiped upon 6 in. pipes. I think the best joint-wiper in the room will admit that it is a good specimen.*

Fig. 3.—View of a Wiped soldered joint.

Over-cast Joints.

OVER-CAST JOINTS.—An *over-cast* joint, illustrated in Fig. 4, is made in the same way as a wiped joint, in fact, it is a wiped joint overcast with

* The joint was shown and admired.

the iron, *i.e.*, directly the joint is wiped, and while the solder upon it is still hot, the neck part of a hot iron is drawn up and down over its surface, forming it into a ribbed joint, or giving it a large number of facets, as shown at b.b.b., Fig. 4. The plumbers of the early part of this century were very clever in making this form of joint. I have seen many over-cast joints as true as it was possible to make them; and though I have rarely seen perfectly true *wiped* joints on the Continent, I have seen many *over-cast* joints perfectly made. But overcasting a joint is time wasted, for though it may give additional strength, and prevent "weeping" in joints made upon service-pipes, when under very great water pressure, a wiped joint is really all that is necessary. A wiped joint calls out, or should call out, greater skill in the joint-wiper, for in overcasting a joint he could regulate with the iron any irregularities in his bad wiping. Over-cast joints are never made now in London by good plumbers.

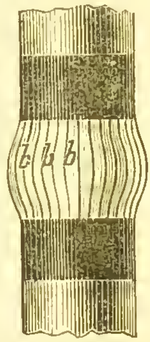


Fig. 4. View of an "Over-cast" joint.

Scotch Joints.

SCOTCH JOINTS.—In Scotland the joints are only made a little more than half the length * of

* Though I do not like "dumpy" joints, I am not at all in favour of very long joints. I think 3½ in. joints are quite long enough for pipes from 4 in. to 6 in. diameter; under that size, say from 3½ in. down to 1¼ in., 3 in. joints are quite long enough; and for smaller pipes a shorter length still.

Fig. 5.
View of a
Scotch joint.

joints made by English plumbers. There is a saving of solder in this; but there is an absence of beauty, and art should count for something; besides, in "funnel" pipes the longer joint is the stronger. Fig. 3 represents an English wiped soldered joint, and Fig. 5 a Scotch, except that in the woodcut the Scotch joint (Fig. 5) is shown longer than Scotch plumbers generally make it.

Upright Joints.

UPRIGHT JOINTS.—An *upright joint* is a joint made upon a vertical pipe or pipes. Fig. 8 shows the two ends of a vertical stack of ($3\frac{1}{2}$ in.) lead soil-pipe ready to be united. The ends of the pipes were soiled and tinned upon the bench before the pipes were fixed in their places. The pipes are brought out 2 or 3 in. from the wall, or a small hole is cut round the sides and back of the pipe, (as shown at M^{Y}, in Fig. 12) for the ladle and the hand to go round the pipes to make the joint. The edge of the outer pipe—the female end—is well closed* upon the inner pipe to prevent the possibility of any solder running through the jointing to form a burr, or any such like evil inside the pipes. It must be evident to the most casual

* Some plumbers prefer not to close the edge of the jointing upon the male pipe. With a quick joint-maker this would make the better joint, as the solder between the two pipes would be of great value, but with slow and inexperienced plumbers the solder would be liable to run through and form spurs inside.

observer, that to make a joint in such a position, a great deal of solder will be wasted if means are not taken to catch the droppings of solder and falling pieces from the joint. Plumbers know this well enough, but do not always take the best means for saving the solder. They place pieces of board or slate round the pipe; or they tie some rags, or a wisp of straw, about the pipe and catch the solder in this rude way; and, when the joint is made, they spend more time in picking off and picking up the solder than they did in making the joint.

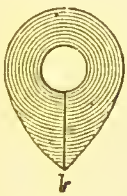


Fig. 6.—Lead Collar.

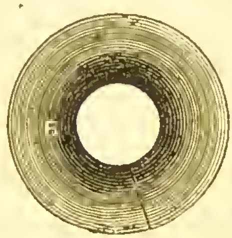


Fig. 6A.—Plan of a Lead Collar when turned up.

"Economy is no disgrace," and economy of time in making or producing a thing is a virtue which carries with it its own reward.

Instead of building up or improvising a rough means for catching solder when making joints on vertical pipes, a proper instrument should be used, and this is very readily made and attached to the pipe, and with such means not a particle of solder need be wasted. Figs. 6 and 6A show pieces of lead cut with circular holes in the centre to suit two sizes of lead pipes. Fig. 6A shows the collar turned up, and clipped. These pieces of lead are Collars.

called *collars;* they can be cut out of 5 lb., 6 lb., or 7 lb. remnants of lead to suit the various sized lead pipes. They should be kept well soiled all over, edges and all, to prevent the solder adhering to them. With a well arranged set of "collars," which should be kept ready for use in all large jobs, a man ought not to take more than a minute or two in selecting the right collar, and fastening it upon the pipe, just where it is wanted, about 2 in. below the bottom edge of the joint, as shown at D, Fig. 8. To secure the collar in its position upon the pipe, all that the plumber wants to do is to pull the collar *tightly* round the pipe and turn the points (*b*, Fig. 6) one over the other to clip them, as shown in Fig. 6A, and D, Fig. 8. He should then sprinkle a pinch of dust—which be can easily pick up in a building within a stride or two—to cover over any small space or opening which may be left between the collar and the pipe. As shown in Fig. 6A, and D, Fig. 8, the collar, when on the pipe, forms a "dish" for catching the falling solder. There is this additional advantage with such an arrangement, that the solder collecting in this dish keeps the pipes hot, thereby facilitating the making of the joint.

Splash Stick.

To make an "upright" joint, unless the plumber is well skilled in pouring with the ladle upon his cloth, he wants a "splash-stick" (illustrated in Fig. 7) for splashing the solder upon the pipes. These splash-sticks are made of wood or iron, about 6 or 7 in. long, $1\frac{1}{4}$ in. wide in the spoon

part and $\frac{1}{8}$th to a $\frac{1}{4}$ in. thick. With care, there is no fear of the iron scratching the pipe, for the edges are well rounded. When the stick is made of

Fig 7.—Splash-stick.

wood, the smoke is apt to get into one's eyes, and interfere with the perfect sight just when it is most wanted. In making this joint, splash the solder well upon the upper part of the jointing, round and round, at a little below E E, Fig. 8; keep pulling up the solder from time to time with the splash-stick from the lower part of the jointing to the upper part, for the solder collecting in the dish will keep the lower part well heated. Splash on the solder rapidly, remembering that speed is the soul of joint-wiping, and roughly form the joint with the splash-stick. Then take the rosy-iron in one hand and the solder-cloth in the other, rub the iron over the solder, and pat it into its place with the cloth; then draw the hot iron right round the upper edge of the jointing, at the back, following it closely with the cloth. Do the same at the bottom edge, and then change hands with the cloth and iron, and treat the front half in the same

Making the Joint.

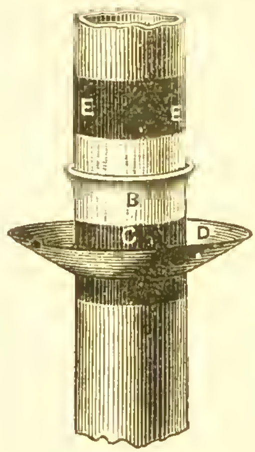


Fig. 8.—View of upright jointing, ready for making.

way, and the joint is made. Before leaving the spot, and while the iron is still hot, rest it in two or three places upon the solder collected on the collar; pull the melting solder into the ladle, and the rest of the collected solder on the collar will then come away in sections, without waste or damage to the pipe.

Branch Joints.

BRANCH JOINTS.—I will not occupy your time in describing the *mode* of wiping *branch joints*, for when a man can make an "underhand" and an "upright" joint, he ought to have no difficulty in wiping a "branch joint;" but there are two points that the learner will do well to remember. (1) When the branch pipe is smaller than the main pipe, the solder will rest readily upon the jointing, but when the pipes are of equal sizes the solder will have a tendency to fall off at the two opposite sides. In jointing such pipes keep the "catch-board," or whatever the solder is caught upon, close to the underside of the main pipe; for the fallen solder will then not only help to keep the pipe hot, but it will also enable the plumber to dip his splash-stick into it, to supply the place of the fallen solder from the sides. (2) As the lower part of the jointing will be kept well heated by the solder upon it, splash the solder well upon the upper part, *i.e.*, upon the branch pipe.

Branch-pipe Connections.

The principle of connecting branches with main soil-pipes, or branches with main waste-pipes, is so

important, that I shall ask your careful attention while describing in detail how the connection should be made.

Socket.

In forming an opening in a lead soil or main waste-pipe to receive a branch pipe, cut an elongated hole in the main pipe, about half the size of the end of the branch pipe to be connected with it, and then work up the sides with a bolt or

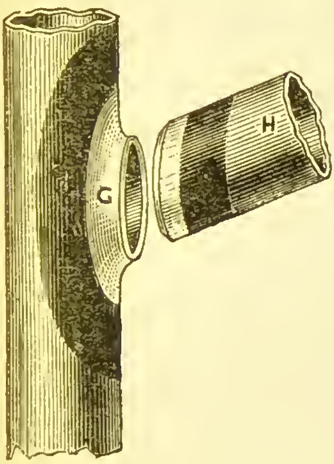


Fig. 9.—View of Branch Pipe connection.

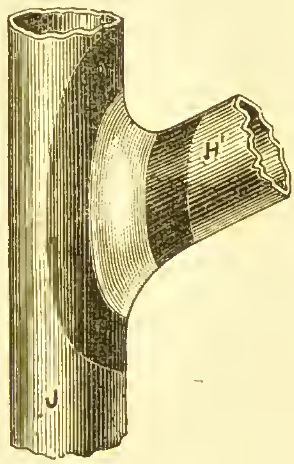


Fig. 10.—View of a Branch Joint.

hand-dummy to form a *socket* upon the pipe, as shown at G, Fig. 9, so that the branch pipe may enter it, about three-eighths of an inch, without coming into the bore of the main pipe to form any kind of obstruction or collecting place there for filth. Great care should be taken that the end of the branch pipe fits well against the sides of the socket all round to prevent any solder running through to the inside when the joint is being made. Fig. 10 illustrates a wiped soldered branch

joint upon a $3\frac{1}{2}$ in. soil-pipe, leaving a clear way right through the main pipe J.

Branches at Right Angles.

No branch pipe should enter a main waste, soil, or drain pipe *at right angles.* In lead pipes, however slight the fall may be, the branch can always be "nosed" * over a little at the jointing for the discharges passing through it, to look towards the way they have to go—but more on this in a subsequent lecture.

Mitre-Joint.

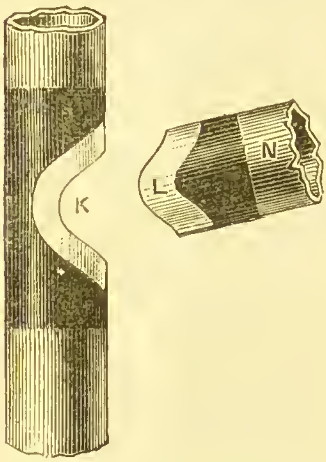


Fig. 11.—Mitre jointing.

The *old* way of connecting branch pipes with main pipes cannot be too severely condemned. If plumbers were also joiners, one could understand how the mitre joint, as shown in Fig. 11, got introduced; but it is difficult to understand why plumbers should make such a connection, especially on waste water or sewage-carrying pipes. Probably one reason is, because they have never considered the matter. They know that it is the best form of jointing in soldering lead nozzles to pump-barrels, for a socket, as shown at G, Fig. 9, could not be properly formed on a stout lead pump-barrel, and as this form of joint had been in use in pump-making long before waste pipes or soil pipes were ever fixed, custom has given it a place in

* See Fig. 106, p. 246.

waste water carrying pipes which it ought never to have. Such a joint takes more time, more solder, and is more difficult to make, than the branch joint shown in Figs. 9 and 10. It is also wrong in principle; for however careful the plumber may be, he cannot leave the main pipe perfectly smooth at K, and the waste discharges from branches fixed on the upper part of the main pipe would have to travel through this badly-fitted branch connection. The edges of the branch pipe N, or of the main pipe K, Fig. 11, must form in some degree a collecting place for filth, and the solder in making such a joint would be more liable to work through the jointing to the inside of the pipe than it would in the other form of branch connection, Fig. 9. We must have *all* the details right, if the whole of the plumbing work in a house is to be sanitarily perfect.

Block Joint.

BLOCK JOINTS.—When soil-pipes are fixed in chases inside the house, there is no stronger way of fixing the pipes and connecting them together than by *block joints.* This joint is easily wiped by a skilful plumber. In making such a joint, round off the block as shown at Q, Fig. 12. Cut out a circular piece of lead, called a flange, about 5 in. larger in diameter than the diameter of the pipe; then cut a hole out of the centre of this flange, a little larger than the outside diameter of the pipe. Soil over both sides and the edges of the flange; dry it over the fire,

or with an iron, and shave it so as to get about 1½ in. of margin on the inner edge for soldering upon. Grease over, and then tin the shaved part of the flange, and put it over the end of the pipe, and taft over the pipe upon it in a round form, so as to get a body of solder *under*, as well as *over* the tafting, as shown in the section, Fig. 12. Never taft over a pipe in such a way as to get a *square*

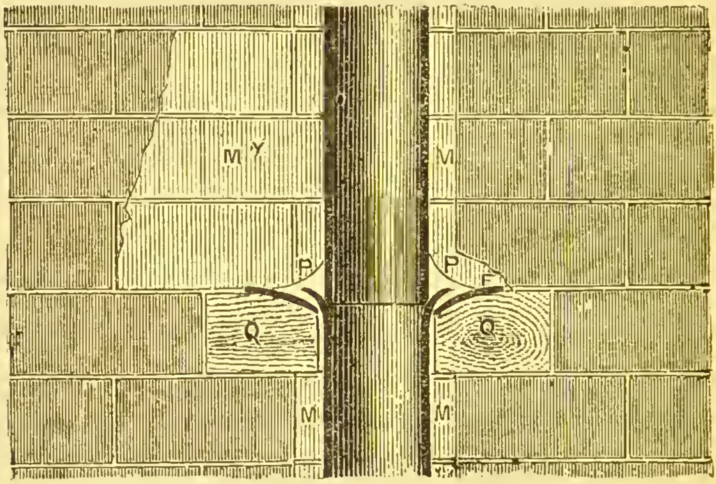


Fig. 12.—Section of a Block joint.

edge next the pipe, for in so doing the pipe would not only be very much weakened by it, but you would not get such a hold of solder upon it, and the joint would soon break.* Open the pipe with a "turn-pin," to allow the end of the upper length to enter (without contracting it in the least) about

* Specimens of badly-made joints with square-edge taftings were shown, with the pipes broken away from the under side of the joints, *i.e.*, at the edge of the tafting.

$\frac{3}{8}$ in., and well tin the end of the upper length before putting the pipes together. I need not say a word about wiping this form of jointing, except this :—See that the pipes are well fitted, to prevent the solder running through to the inside, and splash on the solder quickly, rub a well-cleaned hot iron round and round it, and wipe the joint dexterously. The chase in the back wall is shown by the letter M; and M^{Y} shows the brickwork cut away for making the joint. The flange is shown at F. This flange should always be tinned before being put in its place.

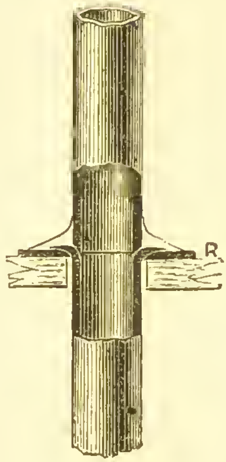


Fig. 13.—Section of a Flange joint.

Flange Joint.

A *flange joint*, as shown in Fig. 13, is made in a similar way to the block joint just described. It is chiefly made on waste-pipes, and small pipes where they pass through a floor. In fixing the pipe, working from the bottom upwards, the top end of the pipe is made to stand an inch or two above the level of the floor. A lead flange (R, Fig. 13), as described in the block joint, is then put over the end of the pipe, and a piece of board, about $\frac{3}{4}$ in. thick, is placed on the flange for the blade part of the saw to rest upon, as a guide in cutting the pipe off to the requisite length for tafting. When the pipe is cut off, the board is removed, and a turn-pin is driven down into the pipe with one or two sharp strokes of the mallet,

and the end of the pipe is then tafted back upon the flange. A section through a flange-joint on a 2-in. lead pipe is shown at R, Fig. 13. The making of the joint, and the connection of the upper pipe with it, need not be described, the thing speaks for itself.

Taft Joint.

A *taft joint* (Fig. 14), is the simplest form of wiped joint. It is made by tafting back the end of the lower pipe, as shown at S, Fig. 14, for the solder to rest upon, and the joint is so simple to wipe that the poorest joint-wiper can make it. But the joint is inferior in strength, in funnel pipes, to the block joint or round joint, and wherever it is found it is a mark of the want of skill in joint-making of the plumber who made it. When a pipe is tafted back to get a sufficient base for wiping such a joint on light pipes, the outer part of the "taft" gets very much reduced in substance; and, by the time it is shaved for the solder to adhere to it, there is little or no strength of lead left in the taft or base, as may readily be seen by reference to the diagram, Fig. 14, at S. Consequently such a joint can never be a very strong one, and is very liable to be a weak one. As for its elegance, look at it, gentlemen and joint-wipers, and judge for yourselves. "Look on this picture, (Fig. 14), and on that (Fig 12)."

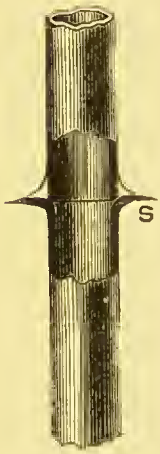


Fig. 14.—Section of a Taft joint.

Sanitary way of Joining Pipes.

I have dwelt at length upon *wiped* soldered joints, because there is a sanitary way of joining pipes and an unsanitary way, and because good joint-wiping is a mark of a plumber's skill. It costs no more for a skilful joint-maker to make a perfect joint, than for an unskilful man to make an imperfect one. Nay, the imperfect joint is generally the costlier, for the excrescence of solder upon it is wasted, and its ugliness is a proof of want of dexterity. Unskilled labour (when skill is wanted) is always more expensive, as it consumes more *time* than skilled labour.

Copper-bit Joints.

Copper-bit joints are not in favour with the London plumber. So prejudiced are some against them, that they never make a copper-bit joint. Every joint is made with "plumbers' solder," and wiped with the solder-cloth. The smallest sized ball-cocks, bib-cocks, stop-cocks, unions, gratings, boiler-screws, caps and screws, plugs and washers, washers and wastes, nuts and linings, &c., &c., are all connected to their pipes or places, irrespective of size, by wiped soldered joints. There is a want of wisdom in this; for copper-bit joints are specially adapted for connecting *small* brass-work, such as unions, and "nuts and linings," &c., to lead pipes, as the copper-bit joint gives more room for the "nut" to move up and down the "lining" than a wiped soldered joint. Besides, well-made copper-bit joints are stronger and cheaper than wiped joints for such connections.

Copper-bit Joints in Soil-pipes.

I would not, however, allow a copper-bit joint to be made on a soil-pipe, funnel-pipe, or thin lead waste or ventilating pipe, especially the usual form of copper-bit jointing, as shown at T, Fig. 15, for though the union of the two pipes may be perfect, the jointing would not strengthen the piping, like a wiped soldered joint, as shown in Fig. 3, or Fig. 12. The band of solder round the pipe (Fig. 3) strengthens it, like a belt round the waist of a navvy; moreover, instead of the solder only *biting* a thin edge of piping, (as in the copper-bit joint, Fig. 15) it has a *grip* of fully 1½ in. on each pipe, and the body of strong soldering round such pipes keeps them in good rotundity.

Fig. 15. View of a "Copper-bit" joint.

In soldering brass work to lead, well tin the brass before making the joint—the plumber's mate should do such tinnings at odd times. The "hatchet" form of copper-bit is the best. It should be kept well tinned, and the soldering edges well feathered. The copper-bit "float," or "flow" joint, as shown at U, Fig. 16, is easy to make. When the copper-bit is well heated, so that you can feel a genial warmth from it by holding it within a foot of the face, place one of the tinned edges against the tinned part of the brass work, keeping the head of the bit as near the brass as practicable

Fig. 16. "Flow joint."

to assist in heating it; then push a "strip" of *fine* solder against the other tinned edge of the copper-bit, and the solder will "flow" round the pipe-base, U, Fig. 16. When sufficient solder is formed on the top of the pipe, pull the copper-bit slowly round the jointing, allowing the tinned feathered part of the bit to rest upon the pipe, and keeping the thin edge against the brass work.

Ribbon Joint.

A *ribbon joint*, as shown at W, Fig. 17, is also made with a copper-bit and fine solder. This joint is more difficult to make, but it is a better joint than the "flow joint." A band of fine solder, about an inch wide and $\frac{1}{16}$ in. thick, is formed round the jointing, and this is so dexterously done by some plumbers, that it is difficult to see where the silver-coloured ring commences and where it ends, *i.e.*, there is no mark of the copper-bit left upon the soldering.

Fig. 17. Ribbon joint.

Over-cast Ribbon Joint.

An *Over-cast Ribbon joint* is simply a copper-bit jointing made as just described and overcast with the copper-bit, giving it several facets; Fig. 18 shows a view of this form of joint. When joint-makers fail in putting a true ring, band, or "ribbon" of solder round the connection, they generally overcast it with a copper-bit to make good any unevenness, and when this is skilfully done the jointing looks very neat, and is at the same time very strong.

Fig. 18. Over-cast Copper-bit joint.

Blow-pipe Joints.

A *blow-pipe joint* looks precisely like a copper-bit joint, as shown at U, Fig. 16: the difference is in the mode of making. One joint is made from the heat of a copper-bit, the other from the heat of a flame—from a handful of rushes tied together, or of a flame from a spirit-lamp—by the aid of a mouth blow-pipe. I need hardly describe a blow-pipe. It is a small trumpet-shaped copper tube, about 9 in. or a foot long, with the thin end bent round, and an air-way of about one-eighth of an inch diameter through its smallest part. The larger end, which is about half an inch in diameter, is held in the mouth, and the smaller end is kept near the flame, so as to blow the heat upon the jointing just where it is wanted.

Astragal Jointing

ASTRAGAL JOINT.*—Though I condemned copper-bit jointing, as shown in the woodcut at T, Fig. 15, I am in favour of a strong *fine solder* jointing, for *outside* soil-pipes, as shown at A, Fig. 19, but there is a great difference in the two joints. There is three times the strength of soldering on this jointing, as will readily be seen by a glance at the illustrations, Figs. 15 and 19, though the soldering in the latter (A, Fig. 19) is not shown quite bold enough. The astragals, B and C, can be cut out of ½ in. or ¾ in. strong lead pipe; and bent round and soldered to the funnel pipe,

* This is not the right kind of astragal jointing for *lead rain water pipe*, for as the ends of such pipe should socket one into the other, the female end should be enlarged, so as to receive the male end without reducing its size.

but I prefer them cast in moulds, in strips of a size to suit the size of the soil-pipe. They are very easily bent round on the pipe where they are to be fixed, and soldered to it with a copper bit. The astragals are reversed, as shown at B and C, and the neck part of the upper astragal moulding is opened out a little, and rasped off on the inner edge, as

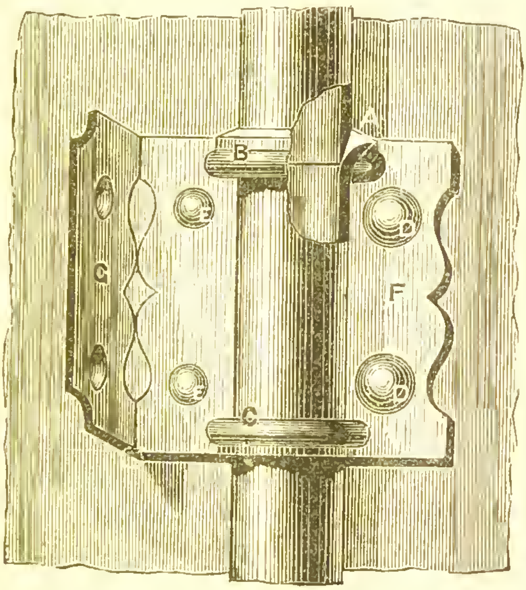


Fig. 19.—View of a Soldered joint with Astragals and Tacks.

shown in section, at A, to give space for a good body of fine solder for making a strong joint. The tacks* are soldered to the pipe in the usual way, and to make them ornamental a device is cut out of the centre part, and dots are raised over the nail-heads, as shown at D. Roundheaded nails are fixed as shown at E, and that part of the tack which is

* See Figs. 97 and 98, showing tacks soldered on.

to cover them is domed back by a tap or two from the small end of the mallet, as shown by the tack G, which is left unfolded for the purpose. The astragals round the pipe help to strengthen it, combining thus the useful with the ornamental. Bacon noticed in his day the neatness of astragal jointings, for he speaks of leaden pipes "bound with leaden bands."

PIPE BENDING.—I now come to the important subject of *pipe bending.* "'Tis a long lane that has no turning," says the proverb, and verily that pipe would be long indeed which had no turning in it. The plumber cannot go far in fixing a pipe—be it a soil, waste, or service pipe—without coming across the necessity of turning or bending it to suit localities; and upon the principle of such turning or bending will depend the wholesomeness, or unwholesomeness—other things being equal—of such piping, if it be a soil or waste-pipe, after it has been in use for only a short time.

Bend or Break.

"Turn or burn" was the "burning" phrase in the martyr days, and the noble martyrs preferred to burn rather than "bend" in their principles. "Bend or break" was the breaking question brought to bear upon stubborn natures, and bend or break is the mode of turning lead pipes. With bad treatment, and in unskilled hands, lead piping is very stubborn, and breaks rather than bends; but in skilled hands it is very pliable, and bends and

turns in any direction the plumber wants, with the grace with which a swan bends its sinuous neck.

"Turn again."

Having made the bend, and turned the pipe in one direction, it will not go far before circumstances will call for it to turn in another. In fact, circumstances will be continually calling for it, like the Highgate bells to Dick Whittington, to "turn again." BENDING, then, is an important branch in plumbing knowledge.

Elbows.

In olden times—and I am sorry to say it is still the practice with many country plumbers—when plumbers wanted to alter the course of a lead R.W. pipe, or soil-pipe, they used to cut the pipe and solder it, *i.e.*, they made an *elbow-joint*, as shown at A, Fig. 20. In making an elbow-joint, some plumbers wipe the joint right round, as shown in Fig. 21. Others make the improved elbow, by bending the heel part of the pipe, as shown at B, Fig. 20.

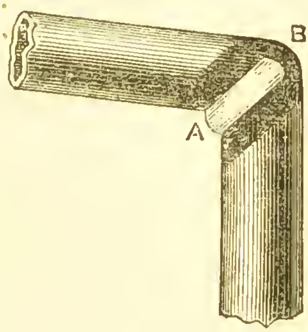


Fig. 20.—View of an elbow-joint.

Evils of Elbows,

There are several objections to an elbow-joint. In making this jointing, one pipe is made to enter the other at the mitre so as to get an overlap to prevent the solder running through to the inside of the pipe. Sometimes one pipe is left to stand up inside the other half an inch or more (I have seen it in old elbow-joints nearly an inch); and the jointing is often made without consideration of the

direction of the water-course through it, so that the "stand-up" inside often forms a check to the discharges passing through the pipe, as shown at A, Fig. 21, and causes the filth to collect there as in a gutter with a stoppage across its bed. There is also the possibility of the solder running in through the connection, or mitreing, and forming "tears" and "spurs" inside. As to its appearance, no sane man would compare it for a moment with a *bent*

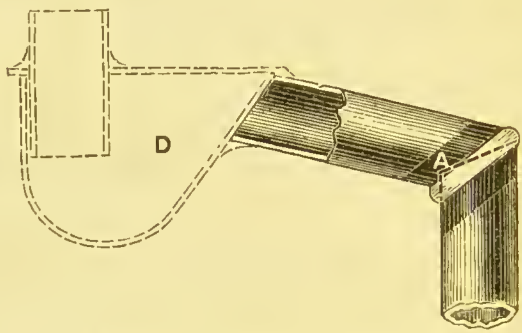


Fig. 21.—Section of the Mitre.

lead pipe, as illustrated in Fig. 27. I am afraid that not one-third of the plumbers in the United Kingdom (leaving out London) could make such bends as the specimens here to-night.

Bending Pipe without Cutting.

The bending of lead soil and funnel pipes (without cutting or soldering them) commenced about forty years ago, but for many years it was only a plumber here and there, very skilled in lead-bossing, that succeeded in making a perfect bend.

Art in Bending Pipes.

There is an art in bending lead pipes. Many try it, but miserably fail. In bending the pipe, they considerably reduce its strength, especially at

the *heel* of the bend, as shown by the illustration in Fig. 22, at E and F. If the strength of a chain is only equal to its weakest link, the strength, and therefore the *safety*, of a stack of soil-pipe, or a stack of waste-pipe, is only equal to its weakest parts; so that when a 10 lb. or a 12 lb. lead waste-pipe, or an 8 lb. or a 7 lb. lead soil-pipe is reduced at the bends to half its original strength,

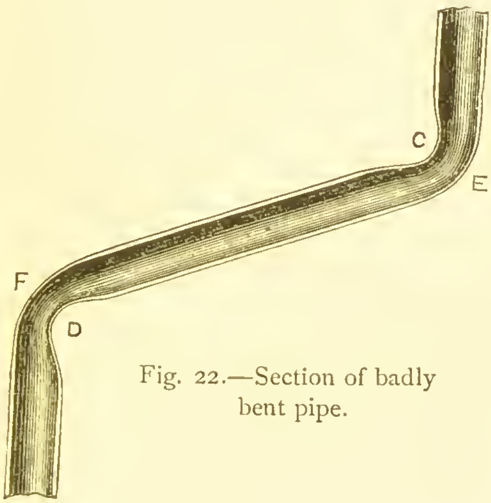


Fig. 22.—Section of badly bent pipe.

the whole length of the piping is depreciated accordingly. But this is not the only evil in badly bent pipes. Unskilled plumbers often *contract* the tubing in the neck part of the bends, and reduce the bore at such points to nearly half the original diameter of the piping, as shown at C and D, Fig. 22. I often notice this as I travel about. Pipes of 4-in. diameter are reduced to 3-in. and less, and when this takes place in soil-pipes, waste-pipes, and

Bends Contracted.

ventilating-pipes, where the tubing should be *quite* of full-bore at the bending, the value of such piping for its work is considerably reduced. If a stack of 4-in. pipe is reduced to 3-in. at its bends, the whole of the stack may as well have been 3-in., and the difference in the cost saved to the householder. I have seen, in bad workmanship, 5-in. piping reduced to 4-in. at the bendings, 4-in. to 3-in., 3-in. to 2-in.,

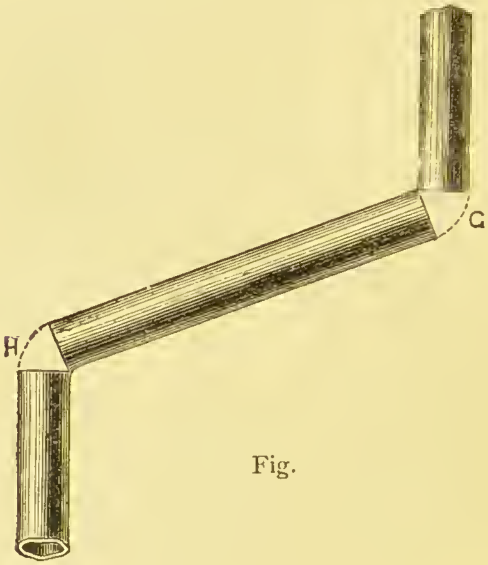


Fig.

2-in. to 1½-in., 1½-in. to 1¼-in., 1¼-in. to 1-in. Now no sanitarian, with any fair knowledge of plumbing, would allow such pipe-bending on any of his works. All these pipes, if they had been bent by men skilled in their trade, would have been of *full bore* throughout.

Elbow Joints.

In making an *elbow joint*, as Fig. 20, you have to cut out a V-shaped piece of piping, but in making a *bend* you are in want of a V-shaped piece

of piping, as shown at G and H, Fig. 23. The skilful plumber will provide for this, and knowing that he is working a pliable material he will, in bending the pipe, dress the lead round from the neck (C, Fig. 22), where there is a surplus, to the heel (G, Fig. 23), where there is a deficiency.

How to make Bends.

In making the bend in a 3-in. or 4-in. lead soil or ventilating pipe (or any size from 3-in. and upwards), well heat the pipe by a flame from a gas-jet, or from wood shavings put inside the pipe, or by pouring some hot lead or solder upon the part to be bent. Heat the pipe as hot as you can—without melting it, of course; then, if it is a long piping, stride over it with your face towards the end (N, Fig. 24) to be pulled up, and press your hand (with a felt or a thick cloth under it, to prevent the hand from being burnt), upon the pipe where it is to be bent, and get your mate to pull up the end of the pipe, humoring the bending part as much as possible to keep it in a circular form to prevent it from crippling. Lay the pipe down on one side quickly, and, with two or three sharp driving strokes of the dresser, jerk and dress the bulged part (K, Fig. 24) of the piping from the *side* facing you, round towards the *heel*, L, of the bend. Turn the pipe over, while it is still hot, and dress the bulged part of the opposite side round to the heel, in a similar way to that just described. By this means, you will thicken the lead where it had been weakened in bending it, and you will at the same time be giving room for the dummy to work

inside the pipe. Take the dummy, as illustrated at P, Fig. 24, and put inside the pipe, N, and get your mate to knock up the *neck* part of the bend with the bulb of solder, O, on the end of the dummy, P, while you are dressing out the irregularities—dressing the lead ever towards the heel, L, to thicken the lead there. Do not attempt too much

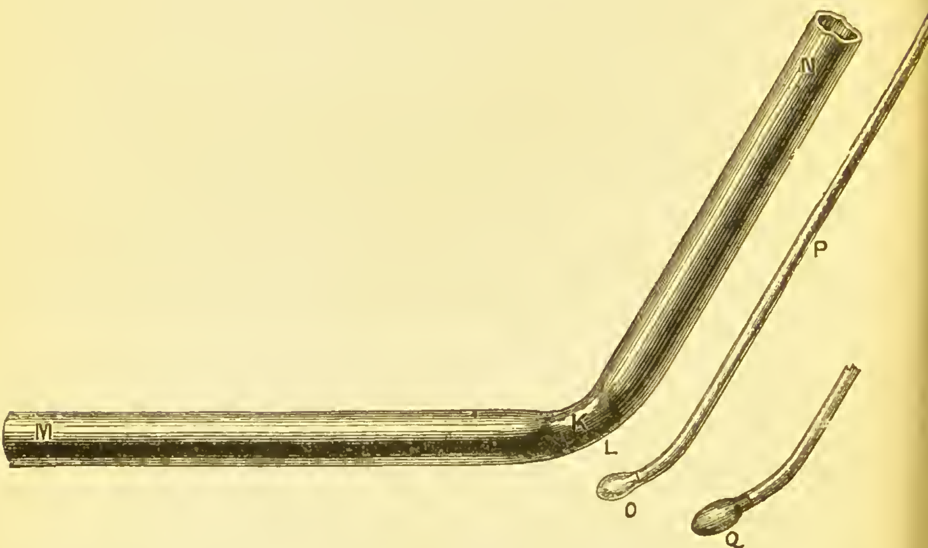


Fig. 24.—View of an unfinished Bend in a length of soil-pipe, and of two long Dummies.

at a time, for to make a good bend, and to make it quickly, several such heats must be given it as I have just described. Watch the blows of the dummy, and see that they are rightly delivered, so that not a blow may be wasted. Fig. 25 shows a hand dummy, which is a very useful tool for the plumber, especially in bending lead funnel pipes. The handle is generally made of cane, and the

Dummies.

dummy of solder. The *long* dummy, as shown at P, or Q, Fig. 24, is wanted in various lengths, but a five feet dummy is a very useful length. Some plumbers make their dummies with pieces of $\frac{5}{8}$-in. iron rod, but the general plumber uses $\frac{1}{2}$-in. or $\frac{3}{4}$-in. gas tubing, according to the length of the dummy.

Young Plumbers.

Some young plumbers, to show that they have mastered the art of pipe-bending, *over-bend* their pipes. Wherever a bend is wanted in a pipe, they make it as sharp as possible. Now no pipe should be bent at a greater angle than necessity requires,

Fig. 25.—Hand Dummy.

and great care should be taken to keep the bend *rounding*, for plumbing is not engineering. It has this great advantage over cast-iron pipe fitting, that lead pipe, by the skilled plumber, can be bent on the *spot exactly* as it is wanted.

Remember that no bend is properly made in a lead pipe, where the lead is in any part reduced in strength below its original substance.

"Bobbins and "Followers."

I am told that it is the practice now with some plumbers in bending pipes to use what are called bobbins and followers, for opening out the pipes. The funnel pipe is partly bent, and then a bobbin, as shown at B, Fig. 26, is put into the pipe with one or two followers, which are made of boxwood, in various lengths, as shown in the

illustration, Fig. 26, at F F F. The bobbin and followers are then driven through the bent piping with the "driving-rod," B. Such a means may ensure the pipe being opened out full bore, but it is a most *un*skilled way of doing it. A *hedge-carpenter* could manage to drive a bobbin (and followers) through a pipe as easily as he drives down a gate-post, but for a *plumber* to adopt such means proves that he is not an observant man;

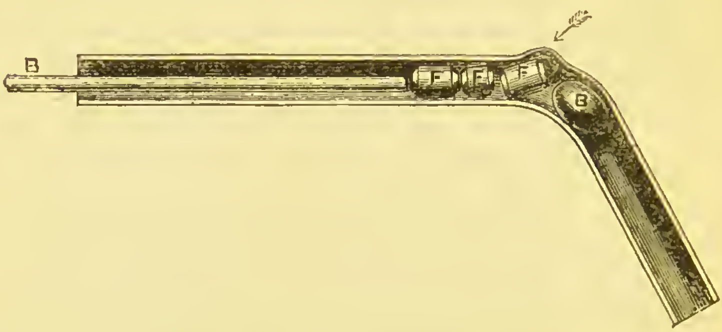


Fig. 26.—Section of a bent pipe, showing the evils of "bobbins" and "followers."

Tools for Bending.

otherwise he would know the nature of the material he is working upon. He would know that in bending a pipe he would weaken it in places, and then, without troubling to strengthen it to its right substance, he would drive this bobbin through the pipe with its followers, reducing the strength of the lead in the weakest parts (perhaps) to bursting points, as shown at F, with the arrow pointing to this evil. All the tools a man wants, to make a perfect bend or bends in a lead funnel pipe, as illustrated in Fig. 27, is a dummy and a dresser or two, and, if he cannot

manage to bend a pipe without the aid of bobbins and followers, he had better "bob" out of plumbing, and "follow" some other trade. There are some specimens of bent lead pipe on this board, which I shall be glad for you to examine and criticise when the lecture is over. The bends on the larger pipes were made with the "dummy," and those on the smaller pipes were made with the "bolt." The bolt is a necessary tool in bending light lead pipes of small diameter. The *small bolt*, A, Fig. 28, is generally made of steel, and the long bolt is also generally made of steel, but some plumbers prefer the long bolt made out of ½ in. and ¾ in. wrought iron steam tubing, as shown at B, Fig. 28, as it is lighter to carry; the long bolts vary in length from 2 ft. to 2 ft. 6 in.

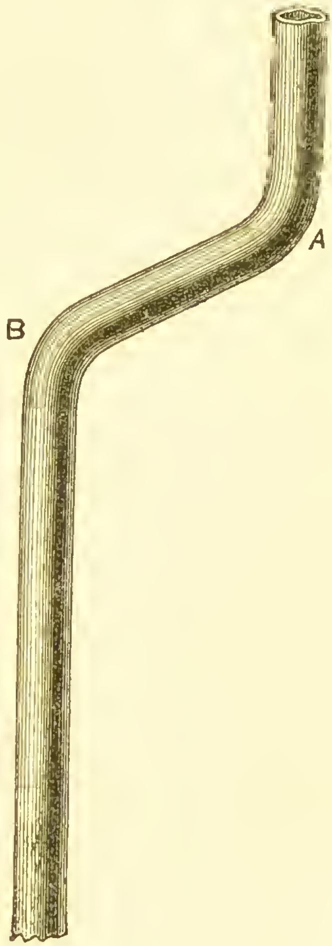


Fig. 27.—View of a double bent pipe.

In making bends in small pipes,* in pipes too

Bends in Small Pipes.

* Specimens of *bent* pipes were shown at the close of the lecture. Inch pipes bent and formed into the shape of the S, and half-S trap; 2-in. and 3½-in. P traps were also exhibited, which had

small for the dummy to work inside, heat the pipe as hot as you can—without melting it, of course—and bend the pipe gently round, giving it as large a radius as circumstances will allow. Then lay the pipe down on its side, placing a *thick* piece of soft leather, or felting, or two or three thicknesses of carpeting, under one of the bulged sides of the bend; and then, with your old cap, or "felt," on the top side (to break the sharpness of the blows), jerk and dress the bulging side back towards the "heel" of the bend. Turn the pipe over, and do

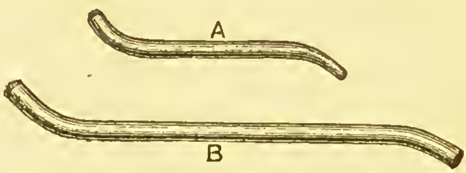


Fig. 28.—Iron bolts.

the same with the other side. Bends can be made in *strong* lead pipes, both of small and large diameter, in this way, by skilled plumbers, without contracting the bore of the piping to any noticeable extent, without the aid of a bolt or dummy. In *light* lead pipes, it will be necessary to open out the pipe, contracted in the bending, with an iron bolt—shown at B, Fig. 28.

Bends in Service Pipes.

Service pipes should also be carefully bent to prevent the bore of the pipe being reduced in any

been bent into such shapes from straight pieces of lead pipe. Letters, forming the word PLUMBING, were also shown on a board, and these letters were bent out of strong inch lead pipe, and were of full bore throughout.

part and interfering with the water supply to the sanitary "fittings," especially to water-closets. Bends* in service pipes are often made in such a way that the sanitary fitting is robbed of its proper flush of water, and made unwholesome thereby.

Plumbers' Efficiency.

When a man can make joints and bends as described to-night, he has, so to speak, the trade of plumber in his hands, and though he may have no intellectual knowledge to boast of, he has something whereof he can boast; for he has educated his hands to do what the most learned professor in the land could not do to-day. His fingers are so educated that he can do almost what he likes with lead and solder; and talent, wherever it is found, should be respected.

Story of the Astronomer.

I daresay you have heard the story of the astronomer and the boatman. The boatman was rowing the astronomer across a piece of water; and the astronomer, wishing to test the boatman's knowledge of the heavenly bodies, asked the boatman what he knew of the stars. Now the starry sky was as a sealed book to the waterman. The vaulted space under its great dome might be an electric-jar for catching the electricity generated by the friction of revolving worlds, and the stars electric lights, for aught the poor boatman knew. Or the stars might be simply holes in Heaven's floor to relieve it of its effulgent splendour. Finding that the boatman knew nothing of the stars, the astronomer called him a "fool." By-and-

* See Fig. 122, p. 275.

bye a storm arose. Now the astronomer would have been perfectly at home in the sky, among the stars; but in the water, among the fishes, he would be "at sea." The storm increased in fury, and the boatman, looking at the astronomer and seeing that he was no longer star-gazing, but getting very anxious-looking, asked him "if he could swim?" "No!" was the reply. "Then, what a *fool* you are," said the boatman, and the boat that instant capsizing, the astronomer's knowledge of the stars did not save him, but the boatman's knowledge of swimming carried him to the shore.

Mind Educated.

But I want plumbers not only to educate their *hands*, but their *minds* as well; and never to be satisfied with themselves until they have learnt the science as well as the art of their trade.

Joint Making and Pipe Bending not all.

When a young plumber has learnt the art of joint-making, and pipe-bending, he is apt to grow contented with such knowledge. In learning to make joints, he poured the molten solder into the palm of his hand as much as into the cloth. He burnt his fingers over and over again, and if he did not dance about for joy he danced about in agony; but he did not give it up; he tried again, and again, and again; now burning his hands, and now burning the pipes—pouring the solder at times right through to the inside. At last, having succeeded in making a good underhand joint, on a 5 in. or 6 in. pipe—like the one now before me—he felt as proud as if he had put a silver band round two hemispheres, instead of round two pipes.

And in learning to make bends in pipes if he did not burn his hands, he constantly burnt the pipes, and that too just when he had nearly succeeded in making the bend. But now he can make a good joint, and a good bend, and is not that enough? No! I tell such plumbers, that joint-making and pipe-bending are but the "three R's"—the stepping-stones to plumbing knowledge. It is but the beginning of the path which leads up to a mountain height of perfection in sanitary knowledge, the *summit* of which has never yet been trodden by the foot of any plumber or sanitarian.

Though there was no time to say more than was said at the lecture, the foregoing subjects will be more complete if something is said here—and it can only be a word or two, for want of space—on the solder used for making the before-mentioned joints, and on lead, tin, pipe, and one or two other methods of soldering.

Lead has a specific gravity of 11,352 (water being taken at 1,000), and melts at 612° Fahrenheit. The weight of a cubic inch in lbs. is ·4150. A great deal of lead comes from our own English mines, but the bulk comes from Spain. Lead.

A *pig* is a piece of solid lead, about 2 feet 3 inches long, 5 inches wide, and 3 inches deep, but it varies in size and shape—of the under side— "Pigs."

and therefore in weight, according to the mould of the manufacturer; and may weigh about 1 cwt. 1¼ cwt., or 1½ cwt. Lead is generally run down into pigs for better transit.

Sheet.

A *sheet* of lead * (milled lead) varies in length and width, depending upon the manufacturer Sheets are rolled from 28 feet to 34 feet long, and from 6 feet 10 inches to 8 feet wide—viz., 6 feet 10 inches, 7 feet, 7 feet 3 inches, 7 feet 6 inches, 7 feet 9 inches, and 8 feet. A sheet of lead can be milled of any strength, from 1½ lbs. to 20 lbs. per superficial foot, or stronger, but above this strength it is called *plates*, and plates of lead can be had of any thickness, from ⅜-inch to 1-inch, or thicker still.

Tin-lined sheet-lead is now made for lining cisterns and sinks, for dietetic purposes, &c., &c The soldering should be done with fine solder using a blowing-lamp, or blow-pipe.

* Fosbroke, in his "Encyclopædia of Antiquities" says (p. 325), "Caylus shows that the ancients used sheet lead, and speaks of a piece of lead but half a line thick, taken from the dome of the Pantheon."

Sir Phillip Howard and Francis Watson took out a patent, in 1617, for an "engine on rollers, for drawing lead into sheets"—for milling lead, in fact. *Cast* sheet-lead is very little used now. We have ceased to make *cast sheet* lead in our factory, though up to about fifteen years ago we made it in large quantities. I consider *milled* lead, made out of *soft* pig lead, much preferable to *cast* lead. An *even substance* can be depended upon in the former (except when the rollers are worn), but in the latter it may vary a good deal.

Lead Pipes.

Lead pipes * are made in every size from $\frac{3}{16}$ths to 6 inches diameter by hydraulic pressure, and almost any strength.† Inch pipe and downwards are made in London in 15 feet *lengths*, or in *coils* of about 60 feet ; above that size—1¼-inch, 1½-inch, 1¾-inch, and 2-inch—they are made in 12-feet lengths, or in coils of from 40 to 50 feet. *Funnel-pipes*, for socket-pipes, rain-water-pipes, ventilating-pipes, soil-pipes, and waste-pipes, are made in every half-inch from 2½ inches to 6 inches, in 10-feet lengths. They can be made of any strength lead, from 5 lbs. to 12 lbs. per superficial foot, or stronger. When they exceed a certain substance, and are, say, from ¼-inch to ½-inch thick, such pipes are called *barrels*.

Tin-lined Lead Pipes.

Lead-encased tin-pipe.—This piping is made in every size from ⅜-inch to 5-inch inclusive, and of any strength for which it may be required. We have used it in large quantities for water-services for dietetic use. It requires great care in making the joints, and they are best made with the blow-pipe, though a *quick* joint-wiper will find no difficulty in making underhand joints. The tin is sure to run a little. Brass connectors can be used for coupling the ends of such pipes, without solder, and this is the better method. As I do not believe

* In my book, "The Plumber and Sanitary Houses," I have classified lead pipes for various works.

† See the weights of lead pipes, as required by the London Water Companies, p. 306.

so much in pipe poisoning * from lead pipes, I have not so much to say in its favour, especially as I consider stout lead pipe, though of less cost, more durable.

Plumbers' Solder.

Plumbers' solder † is made out of two parts of lead and one of tin. ‡ It is generally made in *casts*, from prints stamped in sand, put into flasks, or spread out in level beds. A cast of solder is illustrated in Fig. 28[1]. A, shows a view of the top side, and B the under side. It has eight bars, and weighs about 56 lbs., or 7 lbs. per bar.

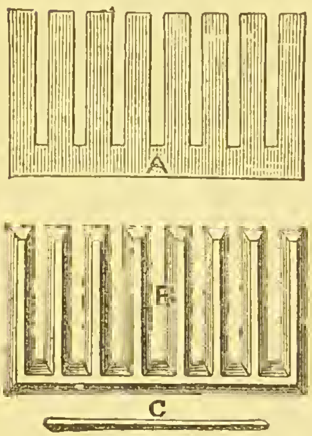


Fig. 28[1].
Cast of Solder, &c.

Fine Solder.

Fine solder, or *copper-bit solder*, is made out of about eight parts of tin to seven of lead. It is run into *sticks* (from grooves sunk in iron plates)

* See p. 291.

† *Soldering* is mentioned in Isaiah xli., 7; and Pliny and Plutarch have something to say on *solder* — called *plumbus argentarius*—made of lead and tin. But I am not going into its history. If the ancients had to go to the East for their wise men, they certainly came West (Great Britain) for their *tin*, and that, too, in early times. "Soft soder" seems to have been used from the very beginning, but its mixture is so very various that I will not attempt to give the ingredients out of which it is made, even if I could.

‡ See foot-note, p. 35.

about 18 inches long, $\frac{1}{2}$ inch wide, and $\frac{3}{8}$ inch thick. A "stick" of fine solder is shown at C, Fig. 28'.

Blow-pipe Solder.

Blow-pipe solder is made with about seven-and-a-half per cent. more of tin than *fine solder*, or fine solder is melted down and enriched by adding from 5 to 10 per cent. of tin to it. It is run out, upon faced iron plates, in thin narrow *strips*, about $\frac{3}{16}$ths wide, $\frac{1}{12}$th thick, and 18 inches long. Cotton and Johnson's patent "Torch" is a very useful means of getting a good flame jet for making blow-pipe joints.

Tin.

Tin has a specific gravity of 7,291, and melts at 442° Fahrenheit. Alloyed with lead it forms *pewter* and *solder;* with small proportions of antimony, copper, and bismuth, it forms *block-tin*, *Britannia*, &c.; and united with copper in different proportions, it forms *bronze*, *bell-metal*, &c.

Soft Solder. Alloys and their Melting Heats.

*Soft Solder.**—Tin 1 part, and lead 10 parts, melt at 541 deg. Fahrenheit; tin 1, and lead 5, at 511 deg.; tin 1, and lead 2, at 441 deg.; tin 1, and lead 1, at 370 deg.; tin 3, and lead 2, at 334 deg.; tin 2, and lead 1, at 340 deg.; tin 3, and lead 1, at 356 deg. Tin 4, lead 4, and bismuth 1, melt at 320 deg.; tin 2, lead 2, bismuth 1, at 292 deg.; tin 1, lead 2, bismuth 2, at 236 deg.; tin 3, lead 2, bismuth 5, at 212 deg.; tin 5, lead 3, and bismuth 3, at 202 deg.

* Extracted chiefly from "Appleton's Dictionary of Mechanics," . 590, Vol. II.

Fire-place.

I need hardly say a word on *fire-places* for heating pots of solder. A good fire-place is essential where a large amount of soldering is wanted—if it is to be expeditiously done. In jobbing work, where the plumber cannot use a modest stove in the house, he prefers *going* to the devil—a well-known fire-grate—rather than go into the kitchen for his heat, to be *sent* to such a quarter by the cook. The *heat* in kitchens is generally too great for men with "metal" to stand it. If the plumber happens "to be without a devil"—a position "devoutly to be desired," I should say, by others as well as plumbers—he can easily make a fire-place with a few bricks. A plumbers' stove is shown in the view which heads this lecture, and it is a great improvement on the old fire-grate. But the plumber, especially the jobbing plumber, can, if he chooses, be independent, in a large majority of cases (except in new buildings) of fire-places, pots, ladles, and irons, and I recommend him to take up his independency in this matter by using some such means as hereafter described for his solderings.

Self-acting Blowing-lamp.

Self-acting Blowing-lamp.—This apparatus is illustrated in Fig. 28², and it is all the plumber wants, in many cases, for melting his solder, for making small joints, and for repairing-jobs. Some of our men have been using this lamp for years, for making joints with fine solder, &c., but it is not in such general use with us as I should like. Mr.

R. Smith, of Messrs. Barnes and Smith, showed some very nice wiped joints at one of the lectures, which he had made with this process. The lamp is a French invention. It has been improved upon, but there is room for another improvement. The hinged wind-guards, D, would be better if they were made to take off, for getting the lamp, when so wanted, into confined places.

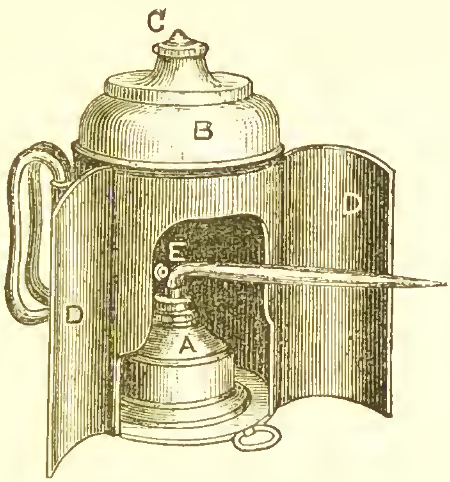


Fig. 28².—Self-acting Blowing-lamp.

The lamp, A, should be filled with methylated spirit, and the wick (common lamp-cotton) should be kept well in front of the jet, E, to prevent the blast from jumping. The boiler, B, should never be more than half-filled with methylated spirit, and the safety-valve, C, should be loosened and cleaned from time to time, to prevent its sticking and bursting the boiler. One of our men narrowly escaped an accident some time ago through neglect-

ing such a caution. These lamps are made in several sizes, and are used for various purposes. An upright joint, or branch joint, of any size, can be made with this lamp in a very short time after the pipes are prepared—say, from five minutes to twenty—depending, of course, upon the size of the joint and the skill of the joint-maker. Underhand joints from ½-inch to 2-inch are easily made with such a lamp, but large underhand joints are difficult. The lamp is not so helpful for soldering sinks and cisterns as well-heated pots of solder. For making wiped joints, &c., with such lamps, plumbers' solder should be run out into thin strips, say about ¼ inch thick, 1 inch wide, and 15 or 18 inches long. This solder is quickly melted upon well-heated jointings from the flame of such a lamp. With a well-directed blast a bulb of solder is soon formed upon the pipings, and heated up to the consistency of wiping. If the joint is too large to wipe right round, the cold parts can be heated up as the wiping proceeds.

Blow-pipe Lamp.

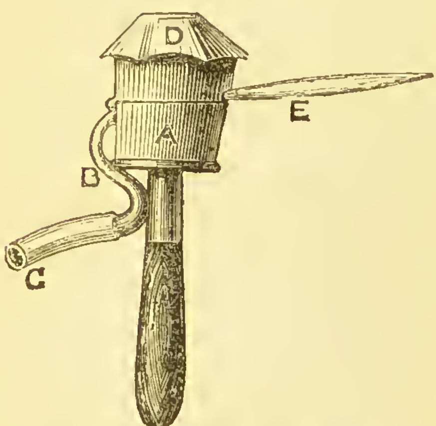


Fig. 28³.—Blow-pipe Lamp.

Fig. 28³ shows another kind of lamp for heating solder, for making joints, and for soldering purposes. The lamp illustrated here is an improvement upon some small

lamps of a similar kind. This lamp was made for us for a special work, and it is very much liked by those who have worked with it. The lamp, A, is filled with common lamp-cotton, and this is saturated with benzoline. A powerful blast is obtained by blowing through the india-rubber tubing, C, which can be of any length, and which is blown by the solderer, or his mate, or it can be blown by bellows, attached to the tubing, or any air-forcing machine, and the lungs of the plumber saved. The solder is melted upon the jointings as explained in the other lamp.

Airo-hydrogen Blow-pipe.

A very valuable method of "soldering" metallic substances was invented in France, in 1838, by the Count de Richemont. This airo-hydrogen blow-pipe was called by the inventor the "Chalumeau Aer-hydrique." The English patent for this invention was taken out in the name of Luke Hebert, in 1838. But Mr. Mallet claims to have used a similar apparatus prior to 1833. The "soldering" done by this instrument is improperly called "*autogenous*" *soldering.* As I shall speak simply of lead joinings—though it is used for uniting various metals—I shall speak of it as *lead burning*, the name by which it is known in the trade. An apparatus complete is illustrated in Fig. 28[4], from one of those now in our possession. It consists of a self-acting and self-regulating gas generator, A B C, for giving a continuous current of hydrogen gas, through the forked-shaped blow-

Lead Burning.

pipe, D, and of a pair of bellows, E, for supplying atmospheric air (through the same blow-pipe) for the combustion of the gases. The organist found to his cost that the organ-blower played an important part in producing his music, and the burner, or solderer, will find, in using this apparatus, that his burning will depend much upon the blower. A good steady stream of air is required to be sent through the tubing, *x a*, for the proper combustion of the gases. Stop-cocks are fixed at S S, in the forked-shape piping, D, to regulate the current of hydrogen from the gas generator, and the stream of air from the bellows. The bent jet-tube can have any sized nozzle, *n*, screwed to it to suit the work to be done. The india-rubber tubings, *a* and *h*, connecting the bellows and hydrogen gas holder with the blow-pipe, can be of any length to suit circumstances. The gas generator is divided into three nearly equal compartments, as shown in the section, A B C. It is about 12 inches by 13 inches, and stands just 3 feet high. The upper and lower reservoirs, A and C, are lined with lead, the lower one, C, being made air-tight. The metals and pipings are united without solder—*i.e.*, by fusion of the metals. A plug is fixed, as shown at *b*, in the upper reservoir, A, over the communicating-pipe, *d*, to the lower reservoir, C. Diluted sulphuric acid,* of

* Our people charge the apparatus by putting 7 lbs. of zinc clippings into the lower reservoir, C, through the aperture, *e*, 3 quarts of water and a pint and a half of sulphuric acid into the upper

the specific gravity 1·16, is put into the upper reservoir, A; and the lower reservoir, C, is filled with zinc clippings through the aperture, *e*, which is afterwards made air-tight. *f*, is a leaden tube, closed by a cork, and through which the saturated acid is discharged. *g*, is a safety chamber, into which the hydrogen generated in the reservoir, *c*, is conveyed by means of a tube, *m*; *k* is a stop-

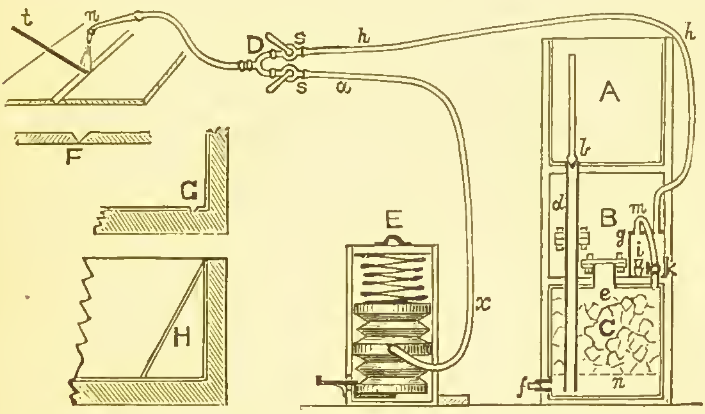


Fig. 28[4].—Airo-hydrogen Blow-pipe and Apparatus.

cock fixed in the tube, *m*; *i* is a tube fixed in the safety-chamber, G, with a cork stopper, which acts as a safety-valve to prevent explosion; P is a perforated false bottom, which supports the zinc clippings in the lower reservoir, C; *n* is the brass jet-tube, screwed to fit the various-sized nozzles through which the gaseous mixture escapes.

Very *intense* and *forcible* jets of flame can be

reservoir, A. A pint of acid is added about every two hours. The zinc lasts eight or ten days. The saturated acid should be drawn off after each usage.

obtained by this airo-hydrogen blow-pipe, at any rate sufficient to melt strong platina wire. For neat burning, it is important to have the right flame-jet. When applied to a bit of shaved lead, the heated point becomes immediately as bright as silver. The following test will indicate with certainty if the mixture and the force of the current be duly regulated; *e.g.*, when the hottest and most reductive point of the interior flame is applied to a piece of shaved lead, the heated point becomes immediately as bright as silver, and the flame itself assumes a violet tint, produced by the volatilisation of a small portion of the lead. When there is too much or too little air, the heat is not so *intense* or *pointed*, and the melting spreads over a larger surface owing to its being heated more slowly.

Two pieces of lead can be united when they only butt against each other, as shown at F, but it is better in many cases to make one piece lap over the other. The parts to be united should be shaved bright (the width required for the burning) and a narrow strip of thin lead, as shown at *t*, shaved bright, should be held in the left hand for supplying the lead required for filling up the uneven space of the joining, or for making a raised seam. In lining cisterns and sinks, for burning under this process, the sides and ends should turn on to the bottom a little, say, ½ inch to 1½ inches, and butt against each other, as shown at G, so as to get a flat surface burning for uniting the bottom with the

sides; and the sides of the cistern should be connected with the ends in a *diagonal* line, as shown at H, the under-piece forming the overcloak—at the lappings—for easier burning.

I consider that every young plumber* should learn this method of uniting metals, for it is very valuable. It requires a good bit of practice, like joint-wiping, to become skilled in lead burning. We have used this method for the last twenty years for making sinks, and lining cisterns and tanks for chemical works; and we are using it on the flêche which is now being erected on the Central Hall of the New Courts of Justice, which will be, when done, the most elaborate piece of lead work, I should say, in the world.

Copper-bit Burning.

Two pieces of lead can easily be burnt together with the aid of a hatchet-shaped copper-bit. To do this, shave the edges to be united, put a piece of brown paper under the joining, and pull a copper-bit—heated nearly red-hot—along the edges, using a narrow strip of thin lead, well shaved, for making good the seam. The tinned edges of the copper-bit should be preserved as much as possible, and they should be brightened up, by pulling the end of a stick of fine solder over them, before commencing the burning.

* This is one of the many things they could learn at a School of Plumbing, if such a place existed.

LECTURE III.

TRAPS.

The necessity of Traps proved by Practical Experiments. Untrapped Waste-pipes to Sinks, Lavatories, &c. Untrapped Soil-pipes; Mr. Norman Shaw's principle. Stacks of Soil-pipes with Untrapped Water-closets upon them. Traps which form themselves into collection-boxes or cesspools. Non-cleansing Traps;—The D-trap; The "improved" or *narrow-band* D-trap; The "Helmet" Trap; The "Eclipse" Trap; The Bell Trap.

Traps, variety of meanings.

OUR subject to-night is "Traps and trap ventilation." As the word *trap* has such a variety of meanings, it may be well to state—on the threshold of the subject, and before attempting to "ventilate" it—that the word will be limited to-night to plumbing and drainage. If not thus confined to "home" uses, there is no telling where your thoughts may be wandering during the prosy part of this lecture. Some would be thinking, perhaps, of the *trap-rock* on the sides of volcanic mountains, and travelling in thought where Mr. Whymper travelled on foot, over the trap on Cotopaxi; for, according to Mr. Whymper, that burning mountain is very "trappy" from its base to its summit. Others would be thinking of quite another kind of "*trap*." They would think of the trap which took them up, when, as tired pedestrians, or homeward-bound toilers, with their knapsacks or bags of tools on their

backs, and blisters on their feet, they were trudging along some country road. When the driver of the trap pulled up alongside of them, and asked them to jump up into his trap, and he would give them a "lift," they thought there were no such traps in the world as *four-wheeled* traps. But it is not of such traps that I want to speak, for though they may be great vehicles for traffic, it is of vehicles for a very different kind of traffic that we are here to speak to-night.

Stragetical Trap.

The *strategical trap* is a very curious sort of trap. It is used in many ways, and for various purposes. In the hands of a clever strategist, it is capable of doing almost as much mischief as a bell trap, or an old D-trap. But this kind of trap is also outside of my subject, and it is only manœuvring with the word trap, to introduce it at all. I will, therefore, just give it a passing notice before entering upon the vexed question of drainage-traps. A countryman comes up to London with more money in his pocket than wits in his head. As he walks through the streets (as if he were going over a ploughed field), in clothes not quite of the West-end cut, he is watched by a man who soon contrives to pick up an acquaintanceship. This man "happens" to be going the same way as the countryman, and as he knows a little more of London than the new arrival, he generously offers to show him some of the great sights. They go from place to place, and as they go the countryman slowly opens his heart, and loosens his purse-strings,

for whatever suspicions he had at first are now allayed, for his jovial companion is quite as willing to treat, apparently, as to be treated. But before the day is over, and this mushroom kind of friend has done with him, the countryman finds he has been led into an awful trap. Plumbers may never make such a trap as that, to catch a friend or foe, but some plumbers do make diabolical traps for catching *filth.*

Poachers and Man-traps.

We live in a strange world. "'Tis strange, 'tis passing strange; yet strange as 'tis, 'tis true" that owners of mansions and parks are often more generous to their enemies than to their friends, for they warn poachers, but they do not caution their guests. They write in large letters, on boards nailed to trees in conspicuous places:—

"BEWARE OF MAN-TRAPS."

Guests and Foul traps.

But whoever saw a notice-board on the walls of a mansion, with such words as these upon it:—

"BEWARE OF THE FOUL TRAPS WHICH BREATHE OUT NOXIOUS GASES."

There may only be a man-trap here and there about the grounds, or in the woods, or preserves, where poachers trespass; though there may be dozens of foul traps in and about the house, where the guests are likely to be found daily. And man-traps do not kill; they only catch a would-be thief, and bruise his leg a little; but *foul traps* not only "catch" a friend, at times they give him illnesses, perhaps typhoid fever, and even death.

It is a most iniquitous thing, to my mind, that when soil-pipes, waste-pipes, and drains want trapping off, as they always do, that such filth-collecting boxes as D-traps, bell traps, cesspool traps, and manhole drain syphons should be used.

Traps, or "Collecting Boxes."

Malicious spirits were formerly supposed, among other ways of working mischief, to take the form of *bad smells;* if so, I can well imagine their grin of delight at finding such congenial lodgings to lurk in. Or did they have a hand in the mischief even earlier, by suggesting the forms of such traps (as just referred to) to the minds of the inventors? But I must be practical, and leave such speculations to theorists.

Malicious Spirits.

I have said a good deal on traps elsewhere. As it would be impossible, in the brief space of an hour and a half, to do more than enumerate all the traps now in use—for their name is legion—we will confine our attention to-night to the general traps most largely used for trapping off waste-pipes and soil-pipes. I am afraid we shall not have time to examine those used for trapping off drains, sewers, and cesspools. In examining these traps, we shall touch upon the principles of nearly all the traps in use.

Traps, legion.

In criticising certain traps, which I consider totally unfit for the purposes for which they are chiefly used, I may be condemning traps which many here may consider good and efficient traps. I will not ask anyone to surrender his opinion to mine without his judgment, "for he that complies

Prejudices for certain Traps.

against his will, is of the same opinion still." All I ask for is a patient hearing, that I may prove my case. I shall be glad, if there are any here who have prejudices for certain traps, if they will clear their minds of such prejudices, that I may have free access to their reasoning faculties. This will not be easy for some plumbers to do in the case of D-traps, for they have been accustomed to make and fix such traps all their lifetime. Moreover, the making of a D-trap was their first great feat in plumbing-practice, and is it any wonder that such a trap should be a favourite with them ?

Necessity of Traps.

But I am anticipating. Before we go into the merits or demerits of traps, we must first prove their necessity, and in this I am sure to have the sympathy of all plumbers and practical men.

Anti-trap men.

As many of you are aware, some men are now condemning the use of traps altogether. True, these anti-trap men are few and far between, but the fact that men are to be found preaching against the use of traps, and practising what they preach (for in their works they do not fix traps to sinks, lavatories, or W.C.'s), calls for some notice from us to-night in dealing with our subject.

To thoroughly examine this question, and to point out the many evils likely to arise from *un*-trapped waste-pipes, soil-pipes, and drains, would occupy several evenings. But it will not take long to show that serious consequences are likely to

arise out of such untrapped pipes. I will, therefore, point out in a few sentences the general arrangement of such wastes, and prove, by one or two practical experiments, that the advocates of *untrapped pipes* are utterly wrong in their teachings.

Waste-pipes as Ventilators

Untrapped Waste-pipes.—When waste-pipes are fixed without traps, as shown in Figs. 29 and 30,

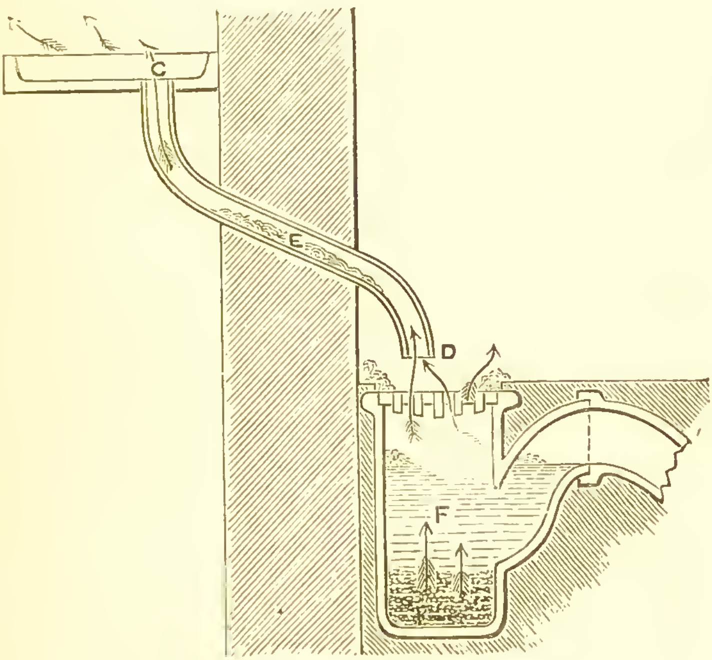


Fig. 29.—Section of Sink, with Untrapped Waste.

i.e., when such pipes are open at both ends, as tunnels, what is to prevent them acting as ventilating-pipes? especially when one end of the pipe is in warmer and more rarefied air than the other, as would generally be the case, one end being connected with the sink (as shown at C, Fig. 29), or

lavatory, bath, or W.C. *inside* the house, and the other end open to the colder and heavier air *out-side* (as shown at D). The fact is, that directly such pipes complete their legitimate work, that of conveying waste discharges, they become *venti-lators*, and help to feed the fires and house with air of questionable freshness and purity.

Now if such waste-pipes can be kept perfectly sweet (a thing practically impossible) no danger can come from such an arrangement, and it would save lazy servants the trouble of opening the windows. Or if it would be possible to prevent the pipes exceeding the length of a short tobacco pipe, I imagine there would be no great risk in fixing such pipes without traps; but as it is impossible to discharge foul water through pipes without fouling them, and as circumstances would demand various lengths for such pipings to reach from the sanitary fitting inside the house to the receiving vessel outside, there can be no safety in fixing waste-pipes without traps.

Waste-pipes get foul.

A waste-pipe from a sink or lavatory, and still more from a urinal, cannot help getting foul, and I think it only wants a little common sense to see this at once. Take the case of a scullery-sink, the general sink in small and moderate-sized houses. The servant throws down into this sink a body of green-water, hot from the saucepan, and before the waste-pipe is dry she turns a tub of hot greasy dish-water into the sink with the washings out of the dripping-pan. Then she

washes her hands in a bowl, using plenty of soap of necessity, to get her hands clean, and the bowl of soapy water, which in the hands of a country lad, and with the aid of a tobacco-pipe, would have sent thousands of soap-bubbles into the air, stains its way down the sides of the waste-pipe, the suds adhering all the way down the pipe to the greasy matter already formed upon it, and "bubbling" itself off in bad air to come back again into the house. Now I should like these anti-trap men to push a pocket-handkerchief through such a waste pipe, as shown in Fig. 29, and then to wipe their noses with it, and try the scent of it as they would a nosegay. Would any one of these men drink a glass of water after it had passed through such a waste-pipe? And yet they do not mind the occupants of the scullery (or where-ever such sinks are fixed) *breathing* the air which has come through such filthy pipes.

Experiments with Untrapped Waste-pipes.

In making this simple experiment which I am about to make, I am but illustrating a very mild case of such open-pipe treatment; for if I had a scullery sink here instead of a lavatory basin, and used it in the way just described, the effect upon the waste-pipe would be much greater than will now be the case. I have here an ordinary wash-hand-basin (illustrated in Fig. 30), and I attach to it a short length of glass tubing, as shown at C, for a waste-pipe. As those who are near me will see, this glass tube which I hold in my hand is perfectly clean. I now connect it with the waste

connection of the W.H.-basin. This done, I wash my hands, using a little soap, and discharge the contents of the basin through the glass waste-pipe in the ordinary way. I now disconnect the glass

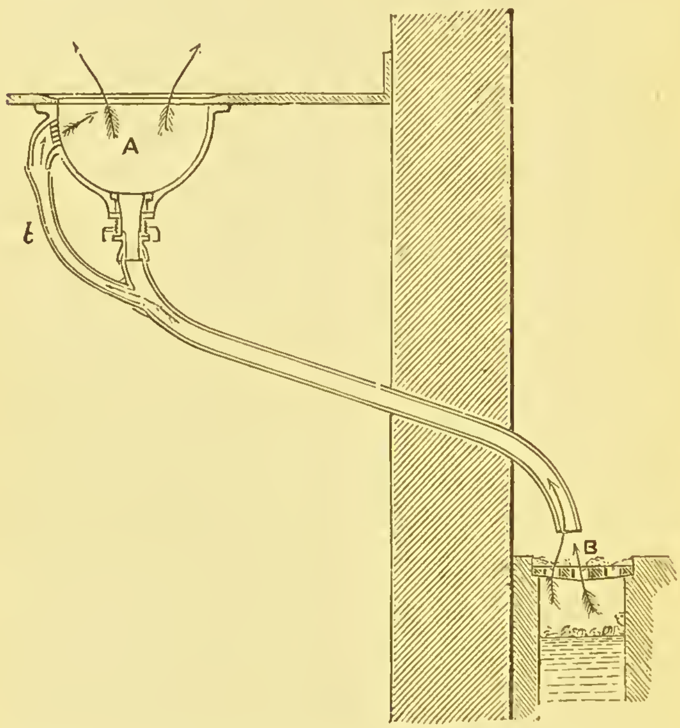


Fig. 30.—View of Basin with Untrapped Waste-pipe.

waste-pipe to see if the passage of the soapy water through it has stained it in any way. There is no doubt about it; but I will pass it round for you to see, and those of you who have average powers of smell will at the same time, by smelling the glass tube, be able to tell me what soap I used

in washing my hands, clearly proving that the pipe has been contaminated.*

Now if instead of using a perfectly smooth surface, as this glass pipe affords, I had used an *iron* pipe, the amount of soap hanging about the waste-pipe would have been much greater, as those who have had only a small experience with iron waste-pipes will know very well. Perhaps some will say, "But iron waste-pipes are never fixed in the manner shown by your experiment." My answer is, that they are, and that too not in ones or twos but in dozens. And they are not only so fixed in cottages, and what are called "Jerry buildings," but in mansions as well—when the sanitarian is abroad—and in an aggravated form, for such waste-pipes are often 2-in. in diameter with a $\frac{3}{4}$-in., or in some cases only $\frac{1}{2}$-in., outlet from the basin into them.

I will now make another experiment, using the same basin, but a different waste-pipe ; for the glass tube just used is only about 2 ft. in length, and in practice the minimum length of such waste-piping would be 4 ft.—what its maximum length may be under certain circumstances, I cannot tell, but I have seen such pipes over 10 ft. in length—without a trap upon them. I will now attach a 5 or 6 ft. length of 1-in. *lead* piping, as that is of a smoother nature than iron; and as lead pipe is generally used, we shall be illustrating the actual thing.

* In making this experiment the soap-suds hung about the sides of the pipe as described.

I wash my hands again (though even ladies would confess that they hardly need it so soon), and discharge the contents of the basin through this piece of new lead waste-piping. I now disconnect it, and by threading a wire through it, I pull a small piece of sponge through the entire length of waste-piping to clean its sides. There's a sponge for a schoolboy to clean his slate with! In practice there would be no sponge pulled through the waste-pipe, but the soapsuds and drainings from each use of the lavatory would be left to dry and corrode upon the pipe; for in most cases the basin and piping would not even be rinsed out with water. The fact is, as all jobbing plumbers know well, that waste-pipes whether from sinks or lavatories soon become foul and offensive. Here is a piece of waste-pipe * cut out from a lavatory, so corroded that it is a wonder how it answered its purpose so long, and the stink from it just after a body of water had passed through it was intolerable.

Corroded Wastes.

In my own house, I had a waste-pipe fixed as an experiment, which did not exceed 2 ft. in length, and though it was only from a small porcelain sink for sundry purposes, the pipe, which was an inch in diameter, and without a trap, soon got corroded, and the offensive smell from the core of collected filth in it was quite beyond imagination.

Lady's Lavatory.

In these two experiments, I have used a simple

* I have not had this piece of pipe illustrated, but it is fairly represented at E, Fig. 29, p. 87.

form of scented soap. I do not profess to be in possession of the secrets of a lady's toilet-table, but if I were a lady, and used this W.H.-basin in my dressing room, possibly I should assist nature a little, and powder up a bit. Perhaps I should also do a little pencilling, to show up the eyelids and eyebrows; and if I were passing over into the "sere and yellow leaf," I might also use a little dye or hair-restorer. Now, though *I* might come out "spic and span" from such a process, I am afraid the *lavatory waste* would not, especially if my attendant forgot to flush out the waste-pipe, as everybody does except sanitarians. It is only fair to attendants to say that however desirous they may be to keep sink and lavatory wastes clean, it is impossible to do so in nine-tenths of such sanitary fittings, for the "mouths" of such pipes are so contracted, or the brass connections or "outlets" from W.H.-basins and sinks are so small, that efficient flushes cannot be sent through the pipes to scour them out. Where good hot water flushes *can* be sent through such pipes, they can be kept tolerably wholesome; but, even then, the pipes should be trapped.

Wastes well flushed out.

No lavatory or sink should be fixed (whether the waste-pipes from them be trapped or not) which will not allow a body of water to be sent through them to more than fill the bore of the waste-pipe; for all sorts of matter is at times emptied into such fittings, and unless good and efficient water flushes can be sent through them to

cleanse it away, the matter adheres to the sides of the waste-piping and decomposes there. I referred just now to the treatment a lady's lavatory often receives, but a gentleman's fares worse, for the short ends of his beard, from his daily shavings, are sent through the waste-piping with the clippings often from his whiskers. Now hardly anything adheres more to a waste-pipe than hair, and the short ends of one's beard, especially when mixed with soapy water—hot and greasy from washing one's hands after oiling or pomading the hair.

Gentleman's Lavatory.

I have said enough to show that waste-pipes in time get very foul and offensive, and more than enough to show that such pipes ought not to be allowed to supply the house with the air needed for breathing, and for feeding the fires.

Lavatory Wastes as Ventilators.

In a gentleman's house recently built, and with its sanitary arrangement carried out under the rules laid down by the Local Board of Health for the Croydon district, I had a test made to see the quantity of air which passed in an ordinary way through untrapped waste-pipes, such as we are now considering. Fig. 29, page 87, illustrates this waste-pipe arrangement. An anemometer was fixed on the grating (C, Fig. 29, page 87) over the top of a 2-in. untrapped waste-pipe of the scullery sink, and between the hours of 9 p.m. on a Wednesday night and 7 a.m. on the morning following, in the first week of April of this year, the anemometer registered 8,205 lineal feet of air as having come into the scullery through this sink-

Croydon Board of Health.

Air-currents in Waste-pipes.

waste; or an average of 820 ft. (lineal) per hour. Of course the air which passed in through this foul* waste-pipe (C D, Fig. 29) would not remain in the scullery, but would pass to any part of the house, to be breathed by its occupants. Comment on such a mode of ventilation is unnecessary. I will, therefore, pass on to consider untrapped soil-pipes to water-closets.

Water-closets sealed off from Soil-pipes.

Nobody attempts to fix a water-closet without having some sort of *seal* between it and the soil-pipe. And though anti-trap men dispense with the water-seal (or trap), they do not fix water-closets without some mechanical means of shutting off the soil-pipe from the closet; *i.e.*, somewhere in the closet, or on the basin "outlet," they contrive to fix an india-rubber or metal valve, or plug, or stopper, to prevent soil-pipe air coming into the house through the closet.

Mr. Norman Shaw's principle.

Untrapped Water-closets.—There are several methods now of fixing untrapped water closets and soil-pipes; and if asked to say which of these I considered the most sanitary, I should say that known as Mr. Norman Shaw's. In a letter to the *Builder*, in March, 1878, I condemned this principle, and gave my reasons pretty fully. I will, therefore, not occupy your time to-night by any

* The bad air emitted from a foul gully-trap would also find its way through such a waste-pipe, as shown by the arrows in Fig. 29, p. 87.

lengthy examination of Mr. Shaw's system. Fig. 31 represents his arrangement :—A, the water-

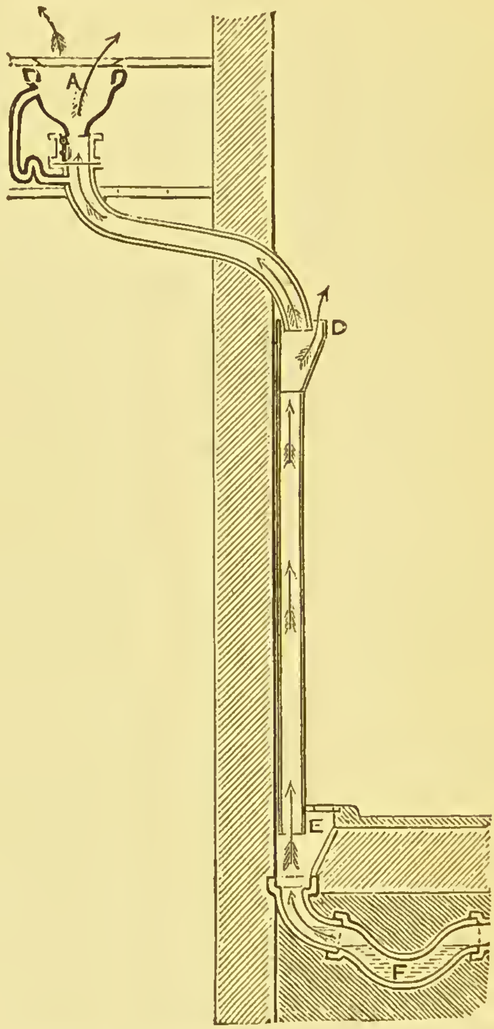


Fig. 31.—Section, showing Mr. Norman Shaw's Principle.

closet (a *valve-closet*) ; C, soil-pipe arm ; D, soil-pipe-head ; E, soil-pipe ; F, drain-trap.

Pipes fouled.

We have just seen how filth can accumulate

upon sink and lavatory wastes. Now if pipes for conveying "dirty water" get foul, how much more must pipes which take away the excremental discharges sent through a water-closet? I am quite willing to admit that if large and efficient water-flushes are sent through the soil-pipes after each usage of the closet, such an arrangement as we are now considering may be kept tolerably wholesome, but if the closets were used with *in*efficient water flushes, as would often be the case, the soil-piping must in time become offensive.

1st. The handle of a water-closet apparatus is often pulled only just sufficient to discharge the contents of the basin into the soil-pipe, leaving the deposit which escaped out of the closet-basin, with whatever water there was in it, to stain its way down the sides of the soil-pipes to the drain. Then, as the basin-valve would be closed, there would be no flush of water to follow it to cleanse the filth away, but the excrement would be left to corrode upon the pipe. Discharging W.C's.

2nd. However learned a person may be in the art of pulling up a closet-handle, to give a free passage to the outgoing matter, and to well open the flushing-valve, there would at times be no water in the supply-pipe to come into the closet to cleanse it. I will give one or two reasons why the supply of water sometimes fails. (1.) Because some leaky valve has leaked all the water out of the store cistern, and there is no water to come into the closet. (2.) Repairs are going on with No Water in W.C's.

the water company's main, and the water is "turned off." (3.) The supply-valve, or w.w. preventer, is out of repair, or the cranks or wires have given way. (4.) The water in the pipe is frozen. Of course, this reason is peculiarly the plumber's, for he ought *not* to have fixed the service-pipe where it would freeze; but he has, as many poor victims found to their cost last winter!

Soil-pipes fouled.

To use a closet under any one of the evils just enumerated, that is, without water, would be quite sufficient to foul the soil-pipe, and as one or more of these evils occur at times in most water-closets, the soil-pipe must get offensive.

Urine in W.C's.

3rd. But there is another source of fouling the soil-pipe. A water-closet is often used as a urinal, and the standing water, largely impregnated with urine, overflows down the overflow-pipe into the soil-pipe, and corrodes upon it, for it is seldom in such cases that the handle of the closet is pulled, especially when used by ladies and children. I have known many soil-pipes to ladies' water-closets, *e.g.*, at railway stations, to get so furred that the bore of the piping has been reduced to one-half its original size after a few years' usage.

Soil-pipes ventilating the House

Having shown the probability of soil-pipes becoming foul, it only remains to show how such untrapped pipes may act as *ventilators*. I said a while ago that all untrapped closets had some means for excluding soil-pipe air, and that the

means were chiefly mechanical. Whatever mechanical means may be employed for such purposes, they are sure at times to fail. In the case of water-closets with metal seatings, india-rubber valves, or plugs, there are several ways whereby a failure may arise; for instance, the mechanism itself may fail, or a piece of paper may get between the valve and its seating, or the solid excrement may get caught under the valve by a careless usage of the discharging handle. Now in any of these cases the water would at once escape out of the closet basin, and the soil-pipe air would have an easy passage into the house. As a proof of this, with an imperfect seating of the basin-valve, a little essence of peppermint poured down at C, or even E, Fig. 31, would be smelt by anybody who placed his nose over the closet at A. I hoped to have had an arrangement here for proving this, but the bare statement will suffice, with the aid of the illustration in diagram, Fig. 31, to convince all present that such would be the case.

Danger of Frost.

There are other evils attending such a system (1.) The danger of frost at such exposed points as D and E, Fig. 31, where the wind would readily catch and freeze any droppings of water (from leaky valves, &c.), cork up the pipes with ice, and render the W.C.'s worse than useless. But as this would be more inconvenient than injurious, I pass on to another evil. (2.) The difficulty in limiting the length of the soil-pipe, for circumstances would

Long lengths of Soil-piping.

require it to be of various lengths, and careless people would put no limit to it. Architects do not gain their reputations by designing the elevations of their buildings to suit water-closets. In some buildings the last thing to be considered is a W.C., and so it gets stuck anywhere where there is room for it, without reference to the drainage from it. Make way for a W.C. by pushing back the partition on the right, and the partition on the left, as policemen make a way in the crowd, and then to get a pipe to reach from the water-closet apparatus to the soil-pipe head outside requires a long length, for the porch, or oriel window, or some other projection, has to be avoided.

Soil-pipe air sucked into the House.

This length of soil-piping would generally be filled with bad air, for there would be no ventilation through it, *i.e.*, there would be no circulation of air through it, (except what escaped inside the house through the basin-valve, when open or defective), the pipe being only open to the atmosphere at one end, and that at the lowest. Now this vitiated air in the soil-pipe arm would often escape into the house through an open basin-valve, or imperfect seating, in the manner we have just been considering, and this soil-pipe would then become a ventilating-pipe for supplying the house with fresh (?) air. (3.) The bad air from an offensive dejection would often go out at the soil-pipe and come in at the window; *i.e.*, the soil-pipe *head*, D, Fig. 31, being of necessity in many cases

near a window, and as the window would at times be open, the air driven out of the soil-pipe (by the discharges of the closet) would be sucked into the house by the fires and the more rarefied air inside the house.

Stacks of Soil-pipes with Untrapped Water-closets upon them.—Having examined and condemned what is, in my judgment, the more "sanitary" method of the two (or more) systems of fixing *un*trapped water-closets, I should like to call your attention to the more dangerous one, and I shall be surprised if all do not assent to-night in strongly condemning it. I would not have brought such an insanitary system of plumbing before your notice, did not circumstances call for it; but it is within my knowledge that the plumbing and so-called sanitary arrangements of a nobleman's mansion have been carried out on principles which I am about to explain, and that too within the last twelve months.

Stacks of Soil-pipe with Trapless Closets.

I do not know who is responsible for introducing *stacks* of soil-pipe with *trapless* water-closets upon them, but I believe it is the outcome of two or three would-be sanitarians. A tier of trapless water-closets is fixed on one stack of soil-pipe, as represented in Fig. 32, or in Fig. 33, plate I, and this stack of pipe, having one, two, three, or four water-closets upon it, may or may not be trapped at the bottom. By some it is trapped and ventilated at top and bottom; but by others it is

not trapped at all. In the nobleman's house referred to, where this system (illustrated in Fig. 33, plate I), has been carried out, the soil-pipes are *not* trapped off, or disconnected from the drain, though I believe the drain is open to the atmosphere somewhere in the grounds—three or four hundred feet off.

I have had this trapless closet scheme illustrated, that you may the more easily follow what I have to say upon it; and if you will kindly keep your eyes upon the diagrams, Figs. 32 and 33, plate I, you will easily follow me.

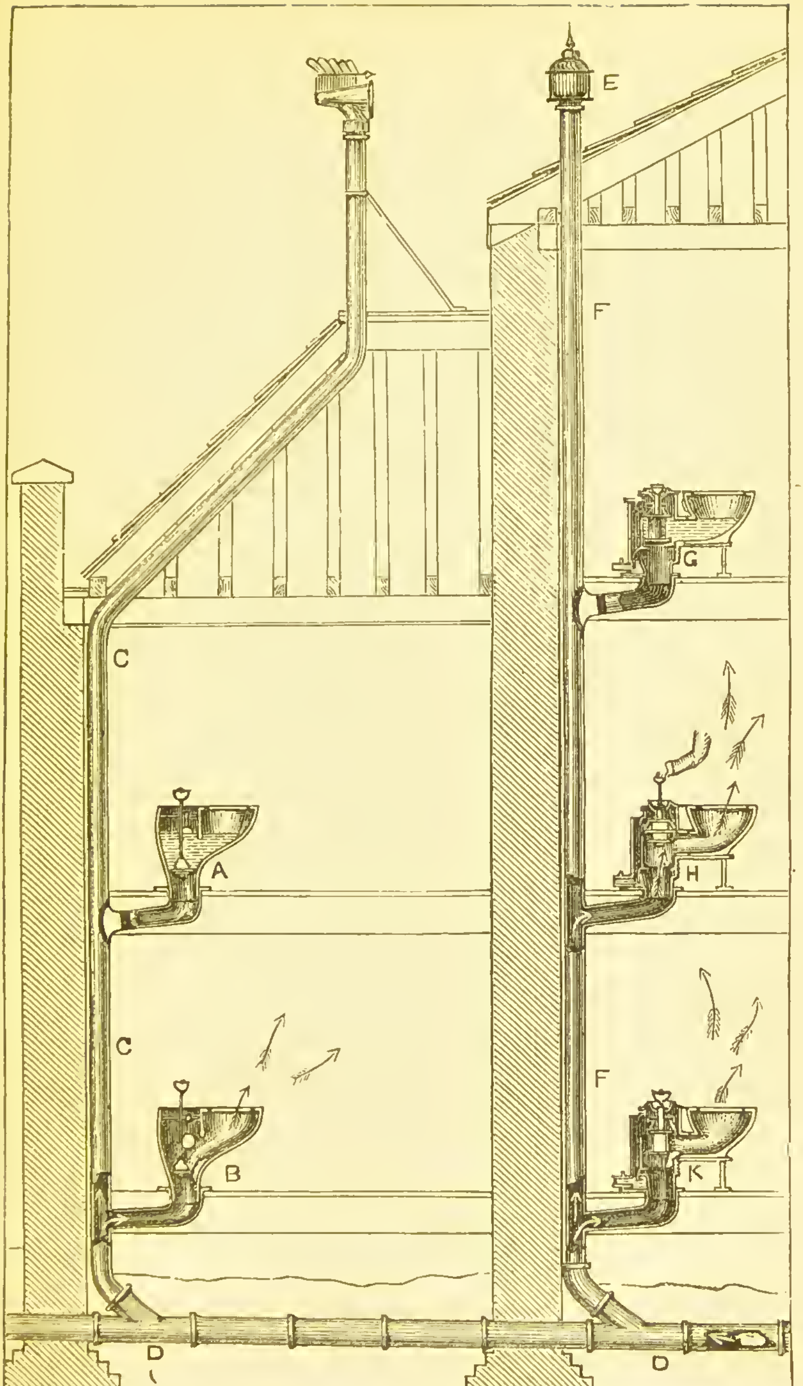
Drain inside the House.

A drain is brought *into the house*, and branches from it are carried under the floors to receive the various stacks of soil-pipe, and R.W. pipes. The drain is carried some distance away from the house before it is exposed to the atmosphere. The various stacks of soil-pipe are continued up through the roof full size for ventilation, with cowls upon them—as shown at E, Fig. 33, and the rain-water pipes, fixed inside the house, are trapped off at their feet.

The branch drains from such pipes must, therefore, be always full of stagnant or drain air, except when the traps to the R.W. pipes get dry—through want of rain—then the drain-air would pass up the rain-water pipes and into the house, perhaps through a dormer window.

No dependence on the Ventilation.

With such an arrangement as this, there would often be no ventilation at all in one or more of the stacks of soil-pipe. A stream of air, we will



Figs. 32 and 33.—View of two stacks of Soil-pipes, to show the evils of Trapless Water-closets, &c.

suppose, is passing into the drain at its outlet end, where it has an induct-pipe, or is open to the air, but this stream of air will have to push its way through, or move on with it the colder and heavier air of the drain, and by the time it reaches D, Plate I, it will be very slow in its movements, and the first stack of pipe, F, will take it all away; so that little or no "fresh" air will pass on to stack C to air-cleanse that. Or, by the inclination of the main drain, or other local circumstances, the air-flushes may *miss* the first stack of soil-pipe, and pass on to others, where the influences may be greater. The man who could determine which of the two stacks of soil-pipe, represented in Figs. 32 and 33, would be the up-cast pipe, would be a clever man; and yet it would be easier to do this, *i.e.*, to point out the stack which would become the chief ventilating-pipe, than to insist upon each pipe acting equally well as an up-cast pipe.

Soil-pipes acting as Down-casts.

In certain states of the atmosphere the soil-pipes would be acting as *down-cast* pipes, if any movement of air was taking place in them at all, for there is sufficient proof to satisfy every reasonable man that there is no ventilation going on in such pipes at times. And even with cowls upon stacks of pipes having their own inducts, there may be no perceptible movement of air for many minutes together; or if any, the tendency is downwards rather than upwards in certain states of the atmosphere, and this downward tendency

is helped by any discharges from the water-closets into the soil-pipe at such times.

Air stagnant in Soil-pipes.

It would, therefore, be quite possible for one or more stacks of soil-pipe to become filled with bad air. Excremental matter would at times be left unwashed out of the soil-pipe or drain, and the gases rising from this would ascend, as shown by the arrows at L, into the soil-pipes, even though there was no perceptible movement of air in such pipes; for excrement gases readily ascend; but the cold heavy atmosphere outside, resting like a valve upon the top of the soil-pipe or cowl, would prevent circulation through them, and so such pipes would become full of bad air. Now, where a defective basin-valve exists from causes already explained, this vitiated air would find an easy passage into the house.

Escaping into the House.

It would also readily escape when a piece of paper, or other matter, got caught under the plug seating, as shown at B, Fig. 32, and K, Fig. 33. This bad air from the soil-pipe and drain would also easily come into the house—especially if the house were well warmed—if the handle of the W.C. were pulled with a *dry* closet basin, or with the water supply to it "off," as shown by the arrows to closet, H, Fig. 33. We have seen how the water supply to W.C.'s at times fails, and we most of us know how, when we want the water to come into the closet, we keep pulling the closet handle, though we may know that the water is locked in ice in the service-pipe, or that the cistern is empty. Now all the time the basin-valve or plug (H) is open, the

soil-pipe air—and in this case drain air too—is coming freely into the house, whether noticed or not; and here is the great value of a trap under or in connection with the water-closet—an air-barrier to stand ever between the house and the soil or waste-pipe, so that whatever else may fail, a *water-lock* in the pipe, to shut out any air travelling through the drain or soil-pipe, shall not.

Air-barrier.

Enough has been said to show that a stack of soil-pipe with a tier of trapless water-closets upon it may ventilate itself, and the drain too, into the house. One or two simple experiments * will make this quite clear.

Necessity of Trapping.

Having proved the necessity of trapping off all pipes for conveying "dirty" water, and sewage—whether waste-pipes, soil-pipes, or drains—to prevent any air, stagnant in or travelling through them, from entering the house, it remains to show the best means of doing this. All that is wanted in well-ventilated waste-pipes, soil-pipes, and drains is a *water-lock;* and the smaller the quantity of water used for such purposes, consistently with circumstances—*i.e.*, giving the pipe a *water-seal*, to prevent an air current in it, and to allow for evapo-

* Glass tubes were fitted up on a board to represent two stacks of soil-pipe with W.C. branches into them, and the drainage from them, as illustrated in Figs. 32 and 33, plate I, facing page 102, (except that there were no cowls on the soil-pipes, as shown in the illustration). By a series of experiments made with smoke it was clearly shown that though the air current, in such an arrangement, might be good in some stacks, it might be stagnant in others, or upwards in one and downward in another. It was also clearly shown,

ration, the more efficient will be its effects. No sanitary fitting, waste-pipe, soil-pipe, or drain, should be trapped in a way that will not admit of the whole of the water in such traps being entirely changed every time a good flush of water is sent into them.

Water in Traps changed.

Traps should only be required to act as *air-barriers* to ward off the air travelling through the pipes, and to prevent it, after it has become contaminated, from entering a house through a bath, sink, lavatory, water-closet, or any other sanitary fitting. But the traps largely used for such purposes are so badly constructed, and the principles on which they are made are so wrong, that they both collect and hold their filth, and turn themselves into little cesspools; here is one such trap, the D-trap. In "Dulce Domum" I may be considered to have said all that could be said against this unsanitary trap, but I must add a word to-night. It is only fair, however, that I should say that one reason why some plumbers prefer the D-trap to the syphon is that it is not easily syphoned out like the latter. But I shall have more to say on syphonage * in my next lecture.

Traps as Air-barriers.

Traps as Cesspools.

D-trap.

About the first form of trap † used for fixing

Syphon-traps.

by the use of smoke in the glass tubes, how drain air and soil-pipe air could readily pass through an imperfect seating of the closet plug, or defective basin-valve of an untrapped water-closet into the house.

* See trap-syphonage, pp. 133 to 174.

† The first patent, No. 1330, for "stink-traps" on record, in the Patent Office—leaving out of consideration the syphon trap which

under water-closets was the *syphon* or *round-pipe* trap, *i.e.*, a pipe bent and recurved in the shape of the letter ∽ ; but as the water in such a trap was easily syphoned out, and as plumbers had not learnt the way of preventing such syphonage by ventilation, the D-trap was invented. In a subsequent lecture * will be shown an illustration of a lead *syphon* trap under a water-closet, taken from a drawing made in 1775, more than a century ago. But I am considering D-traps, and there is proof in the records of the Patent Office, that the D-trap was in use in 1790. Fig. 34 represents about the oldest D-trap, with its cheeks soldered outside to the band. This trap was extensively used during the first half of the present century. The present form of this trap, as shown in diagram Fig. 35, and which has been in extensive use during the later half of this century, is little better than the older one, for though it has a less sudden rise to reach its "out-go," its principle and character are the same.

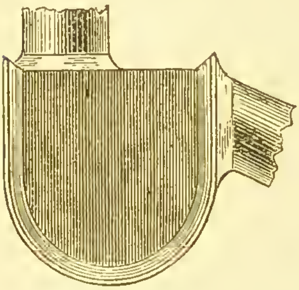


Fig. 34.—View of a D-trap, early shape.

Cummings patented in conjunction with his water-closet—was granted to John Gaillait, a cook, on June 19th, 1782. There is no drawing, but his specification reads as follows :—"The invention of an entire new machine or stink-trap, which can be made of any and all sorts of metal and earthenware, and which will entirely prevent the very disagreeable smells from drains and sewers."

* See Fig. 81, pp. 195, 196.

Sizes.

The larger size, *i.e.*, from 9-in. to 10-in. (measuring from the top to the band, in the usual way) is chiefly used for trapping water-closets. One of our old foremen, who worked at 21, Newcastle Street, from about 1830 to his death, about 10 to 15 years ago, made his D-traps, for fixing under water-closets, 10-in., and for fixing at the bottoms of soil-pipes from 14-in. to 16-in., though the latter were chiefly P-shaped. The smaller sized D-traps, 6-in., 7-in., and 8-in., are used principally (by the plumbers who use D-traps) for fixing under sinks, baths, and lavatories, and for trapping "safe wastes" to W.C.'s. Having said so much elsewhere on its unfitness for fixing under water-closets, &c., it will not occupy much of our time to show that such traps are totally unfit for fixing on "dirty water" and sewage wastes. The average weight of corroded matter (dried excrement) which can be knocked out of an old "full-sized" D-trap, when it is just cut out from a water-closet, and after it has been in use for 10 or 15 years, is about * 5 or 6 lbs.; and the smaller sizes, from sinks, urinals, and lavatories, fare just as badly.

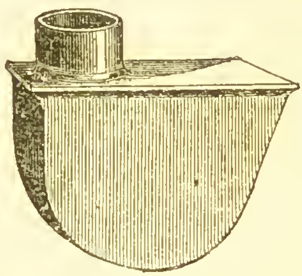


Fig. 35.—View of a D-trap, modern shape.

Corroded matter in D-traps.

Inner Surface of a D-trap.

The *internal* surface of a "full-sized" † D-trap

* The filth knocked out of an old D-trap, which came into our warehouse, just before I prepared this lecture, was 8 lbs.

† A *full-sized* D-trap is made 9-in. (measuring from the "top" to the "band") by some plumbers, and 10-in. by others.

is nearly double that of a 4-in. "round-pipe" trap, Fig. 59, and it is greater still over my "V-dip," or "Anti-D-trap," Fig. 61. In fact, the "narrow

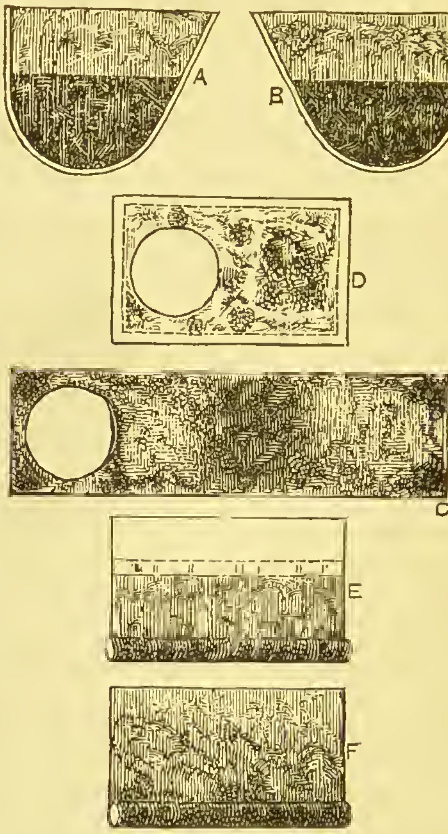


Fig. 36.—Internal surface of a D-trap.

band" D-trap, Fig. 40, is double that of the "Anti-D-trap," Fig. 61, though the way through the former is smaller, *i.e.*, a larger body of water could be sent through the "V-dip" trap in less time

than through the D-trap. The *internal* * surface of a 9-in. D-trap is equal to about 3 ft. 6 in., or 3 ft. 9 in. superficial. It is illustrated in Fig. 36, and the figures can be checked, for it is drawn to scale—the soldering is not shown. There are the inner sides of the two cheeks, A and B, the inner side of the band, C, the under side of the top, D, the outer side of the dip-pipe, E—which stands inside the trap—and its inner side, F. All these surfaces, A B C D E, are exposed to any matter sent through the trap, and they very soon get coated over with excremental matter, as shown in the illustration; but a better illustration is shown of the interior of an old D-trap, in Fig. 36 of my book, "The Plumber and Sanitary Houses."

The misfortune is, that when this large exposed surface of the D-trap became coated over with filthy matter, from settlements and splashings, it could not be thoroughly cleansed again; for no scouring flushes could be sent over the outer side of the dip-pipe (standing down in the trap), the space round the dip-pipe, between the cheeks and the band, and along the under side of the top. But in a round-pipe trap, Fig. 59, and in the "Anti-D-trap," Figs. 61 and 63, the whole of the internal surfaces could be thoroughly cleansed, for good scouring flushes could

* The *internal surface* of a 9-in. D-trap is just 3 ft. 6 in. sup.; in the *improved* or "narrow band" D-trap, Fig. 40, it is about 3 ft. In a 4-in. *round-pipe* trap, as Fig. 59, it is under 2 ft.; in my large size "V-dip" or "Anti-D-trap," Fig. 61, it is 18 in.; and the "small" size ditto, Fig. 63, it is only about 15 in. or 16 in. The "outgo" is not considered in the measurements of any of these traps.

be made to pass over the whole of the interior of such traps with a frictional force.

I will not say any more on this trap for water-closet uses; and instead of occupying your time with a lengthy criticism on the smaller sizes for trapping off what are called "dirty water" wastes, (to distinguish them from sewage wastes, soil-pipes, drains, &c.), we will give a few practical experiments to show their unfitness for such purposes. In doing this, we will not aggravate the case by using the trap unfairly, for instead of using such adhesive matter as greasy water from saucepans, &c., we will use a little soapy water, and after that some plain water with a little stone-blue put into it to colour it.

D-trap for Experimenting.

I have had a small size D-trap made with glass cheeks to it, for you to see the working inside, and this trap is connected to a small wash-hand-basin with 1-in. brass plug and washer, the usual size being only $\frac{3}{4}$-in. This trap is made much smaller than the usual "small" hand-made D-trap, or than the small-size cast lead D-trap, so that any experiment made upon it will be more favourable for cleansing it than would be the case with the D-traps as generally used in practice. Fig. 37 illustrates this trap, B, with a small wash-hand-basin, A, fixed upon it. The depth from the top to the band is 4-in., the width of the band, between the cheeks, 3-in., and the length along the top 6-in. The * dip-pipe first

* In subsequent experiments (See pp. 132–139) the dip-pipe was increased in size to $1\frac{1}{2}$-in.

used was 1-in., and the distance from the bottom of the basin to the standing water of the trap is 8-in. The short length of waste-pipe, C, consisted of a piece of glass tubing.

Two or three experiments were then made with this model, to show the non-cleansing nature of D-traps. Some blue water, *i.e.*, water coloured with stone-blue, was put into the trap, and though two Experiments.

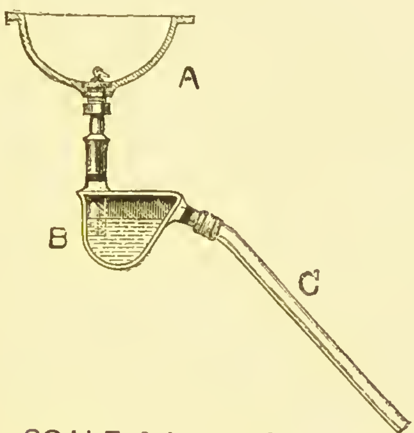


Fig. 37.—View of D-trap and basin.

or three charges of clean water from the basin were sent into it, the whole of the blue water was not removed. The trap was then charged with soapy water, as in practice when fixed under lavatories would be the case, but though several flushes of clean water from the basin were sent into the trap, every vestige of soapy water was not removed, and with one flush the suds remained strongly in the trap, floating about and around the dip-pipe.

The experiments showed clearly enough how such traps become *cesspools*, or *filth-collecting* boxes. And yet there are hundreds of thousands of such traps in use in England to-day, under baths, sinks, urinals, safes, lavatories, and water-closets. But their use has very much declined during the last few years, though probably they are still being fixed at the rate of about four or five thousand a year.

I did not want to exaggerate, but this number is said to be only about half the number of the *cast lead* D-traps used, so the evil is greater than I thought. I was thinking chiefly of the *hand-made* D-trap.

Dip-pipe inside the D-trap.

THE EVIL OF THE DIP-PIPE BEING INSIDE THE D-TRAP.—It is important also to notice the evil of having a dip-pipe inside a trap, for the dip-pipe becoming defective—from age, want of ventilation in the soil-pipe branch, or any other cause—would not show itself, *i.e.*, the dip-pipe, standing inside the walls of the trap, as in a box, would not show a water leak, for any water escaping through a defect in the dip-pipe would fall inside the trap. But though no evil would arise from a leakage of water, great danger may come from a defect in the dip-pipe, for soil-pipe air would then find an easy passage to the house, above the water-lock of the trap, as shown by the arrows in Fig. 38. This illustration is taken from an old D-trap, recently cut out from under a valve-closet. The dip-pipe, right round, above the water-line of

the trap (equal to about 12-in. by 4-in.), is eaten away in large holes, as shown in the illustration, at B. The cheeks are also eaten through, and two or three holes are eaten through the top. This old D-trap shows clearly enough that serious evils may arise from using traps with dip-pipes inside them, for though the defects in the cheeks showed a water-leakage, and called attention to the trap, the dip-pipe, though more defective, and to all appearances of much earlier date, showed no such defect, for the water which escaped through its holes fell inside the walls of the trap and disclosed nothing.

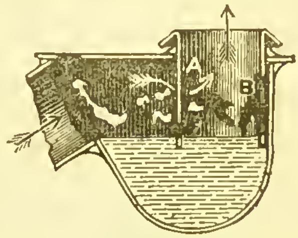


Fig. 38.—Internal view of an old D-trap, showing the evil of a dip-pipe being inside a trap.

The *improved* or *narrow-band* D-trap.—At the discussion which followed these lectures, it was endeavoured to be shown how the D-trap *could* be improved, but it must be remembered that I have been dealing in these lectures with *the* D-trap—the "hand-made" and "cast lead" D-trap—used throughout England, by people who use them at all. I have not been criticising an "improved" D-trap, which had no existence before my lectures, and which was admitted to be quite new, and brought out by my remarks on the non-cleansing nature of D-traps, and contrasting them with the self-cleansing nature of *round-pipe* and "syphon" traps. I should like to examine this "Narrow-band" D-trap.

narrow-band D-trap a little closely. The improvement consists in bringing the two "cheeks" (the sides) of the trap closer together, so as to leave as little space as possible between the dip-pipe and the inner sides of the cheeks, as shown on plan, Fig. 39, *i.e.*, in the *full-sized* D-trap, the *band*, C, Fig. 36, p. 110, is 6-in. wide, but in the *narrow-band* D-trap, Figs. 39 and 40, it is only $4\frac{1}{4}$-in. wide, so that the cheeks of the trap stand closer together by $1\frac{3}{4}$-in., making the trap more compact, and less difficult to flush out. But to call this trap* *self-cleansing* would be misleading, for the *inner* surfaces of the trap are just the same as in the full-sized D-trap, minus about 5-in. sup., for the narrower band and narrower top, *i.e.*, the internal surface of this "narrow-band" D-trap would be equal to about 3 ft. sup. against 18-in. in the large "V-dip," trap, of equal capacity for removing discharges sent into it. No scouring flush could be sent up the two vertical angles, A and B, Fig. 39, nor at D and C, so that these parts would become lodgments for filth; and the dip-pipe, though it

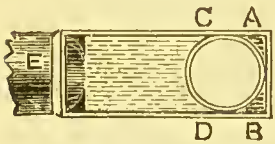


Fig. 39.—Plan of the "Narrow-band" D-trap.

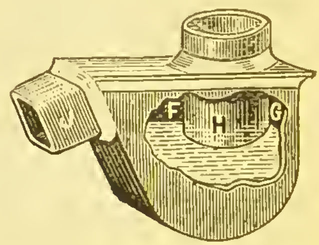


Fig. 40.
View of the "Narrow-band" D-trap, with "square" pipe outlet.

* See tables 1 and 2, pp. 160, 161.

would often get splashed over with excremental matter, would rarely, if ever, get thoroughly cleansed, for no frictional force could be brought to bear upon it, from F G H, and upwards. Then there is the evil of the *dip-pipe* being *inside* the walls of the trap, as explained in the D-trap, p. 115. Fig. 40 shows this trap with a "square" pipe outlet, J; and Fig. 41 with a round-pipe outlet, K. The latter trap forms greater resistance against syphonage, but the former would, I consider, be the more wholesome, as it would allow the contents of the trap a freer passage to the soil-pipe.

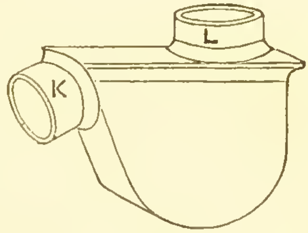


Fig. 41.
View of trap as last, but with a round outlet.

THE "HELMET" TRAP.—The criticisms on the D-trap proper have brought the cast lead "Helmet" trap into notice. This trap is illustrated in Figs. "Helmet" trap.

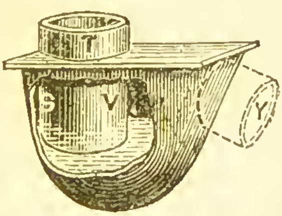


Fig. 42.—View of the "Helmet" trap.

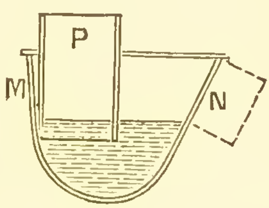


Fig. 42A.—Section.

42 and 42A. I consider it a more wholesome trap to use than the D-trap, for it holds less water, and has less room for collecting filth. As will be seen

by a look at the woodcut, the ends and bottom of the trap are rounded, but being a box kind of trap it is an accumulator of filth, and the evils complained of in a dip-pipe being inside a trap also apply to this one

"Eclipse" trap.

THE "ECLIPSE" TRAP.—A *vertical section* is given of this trap in Fig. 43, and a *plan* of it in Fig.

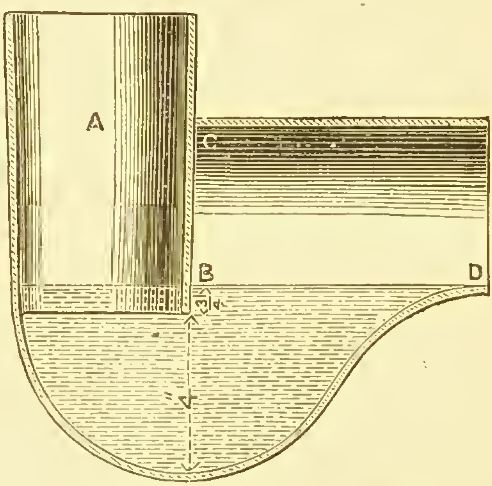


Fig. 43.—Section of the "Eclipse" trap.

44. I have criticised this trap at length elsewhere, and therefore simply enumerate one or two evils belonging to it here. The dip or "seal" of the trap (being slightly under 1-in.) is insufficient to allow for the smallest syphonage and evaporation; in fact, it is not enough, as I consider, to form a *good* water-lock, apart altogether from any consideration of syphonage.

The trap is not self-cleansing, for the *outer side* of half the dip-pipe standing inside the trap, as

shown at B C and E and F, is exposed to splashings of excremental matter when sent into the trap; and though good flushings may follow such discharges, they would not pass with any scouring process upon the parts so fouled. Then there is the risk of a defect taking place in that part of the dip-pipe

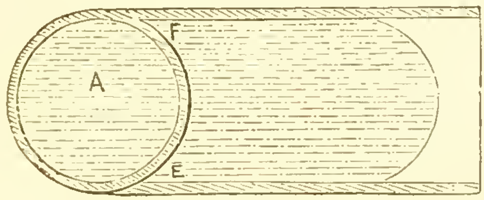


Fig. 44.—Plan.

which stands inside the trap, as explained in the D-trap, p. 115.

BELL-TRAPS.—Next to the D-trap, the bell trap has been most largely used during the last half-century. It is used chiefly for sinks, areas, and surface-drainage. Bell-traps.

It is a non-cleansing trap, and ill-adapted for its work. It can vie with the D-trap in the amount of evil it has achieved. Perhaps it would be impossible, in connection with drainage matters, to find two more fruitful sources of evil than the bell trap and the D-trap; and if it could be possible to collect the number of illnesses and deaths caused through such traps, the statistics would be appalling. But householders—as well as doctors, sanitarians, architects, and plumbers—are getting alive to these enemies of health and sanitation, and their day will soon pass.

A glance at the illustration—diagram, Fig. 45—will show that a bell trap is not self-cleansing. The trench, *b*, round the stand-pipe, *b*, forms a well or ditch for the filth to collect in ; and no flush of water could be sent through the round holed grating and contracted space, C, to keep this ditch clean. The truth is, that such a trap soon gets clogged up with filth, and to remove this filth, or to get a passage through the trap, servants take the top off. In doing this they *un*lock the trap, and leave the house unprotected, as far as that trap is concerned, from the air in its waste-pipe, and perhaps drain too. It is not too much to say that thousands of bell traps could be found at this moment in London with their tops *off*. But when their tops are *on*, there is no great protection from them, for the "dip" or "seal" is so slight that the water soon evaporates, or is drawn out by a piece of rag, sufficiently to untrap them, or to allow the air in the pipe or drain to pass through them.

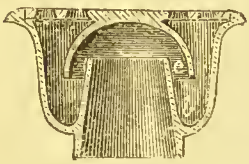


Fig. 45.—Section.

There are many other non-cleansing traps, but as those of which I want to speak are chiefly used in connection with drains, I will defer what must be said about them until we meet again, when I hope to bring before your notice traps which are *self-cleansing*.

The evening is now so far advanced, that I am sure you will be glad for me to pick up my "traps," and go.

LECTURE IV.

TRAPS AND TRAP VENTILATION.—*Continued.*

Non-cleansing Drain Traps—"Mansergh," "Triple-dip," "Drain-syphon." Bad Trapping means Bad Drainage. Principles of Self-cleansing Traps. Trap-syphonage. Experiments with Traps,—the D-trap, the "Narrow-band" D-trap, the "Helmet" D-trap, the "Eclipse" trap, the "Syphon" trap, the "Round-pipe" trap, the "Anti-D-trap," and the "Bower" trap. Tables of Trap Testings. Ventilation of Traps. "Drain Interceptors," "Sewer Interceptors," &c.

Traps—*continued.*

I FIND, according to the syllabus of this course of Lectures, that I ought to have "cleared" the subject of traps in my last lecture; and that to-night I ought to be "entering" upon the question of "soil-pipes and waste-pipes;" but, as I then showed, traps are not so easily "cleared." "The job took longer than I expected," is often the plumber's plea for not getting away from a place sooner; and I confess that this examination of the trap question is taking more time than anticipated—but in all sanitary matters it is much better to "clear away" as we go. Without these preliminary remarks, you may have concluded, by my continuing the subject of traps, that I had fallen into one, and could not get out of it; but you may rely upon my always "moving on," especially where *non*-cleansing traps are concerned; or, as I

have elsewhere called them, "collecting-boxes." People are generally in a hurry to move away from the latter, if they are in no hurry to get away from the former.

Traps, Legion.

The name of the traps now in use is *legion;* to examine each one individually would occupy more time than we have at our disposal.

Drain Traps.

We have considered the characteristic traps used in plumbing works, of the non-cleansing principle—and possibly I condemned them too severely for the peace of mind of many present. Many other traps befoul themselves in use, but I only want to-night to speak of this class used *outside—i.e.*, in connection with drains—before passing on to consider self-cleansing traps. Some may think that drain-traps—whether for receiving waste-pipes, &c., or trapping off the sewer—are "outside" our subject, but I think the journeyman plumber's knowledge ought to cover the whole area of house drainage, and ought certainly to extend to the sewer or cesspool; not for planning, but for carrying out his work intelligently.

"MANSERGH" TRAP.—The first of these drain or stoneware traps for examination is the "Mansergh" trap. Here is one for any one to examine after the lecture is over. Fig. 46 shows a *section* of it. Though this trap has only been in use a few years, comparatively speaking, it has had an extensive sale, and is much liked by many.

Non-cleansing.

I condemn this trap, first, because it is *non-*

cleansing; and secondly, because it does not leave the end of the waste-pipe (discharging into it) *open* to the atmosphere.

A fair look at the illustration, Fig. 46, will show practical men that this flat-bottomed, trunk-shaped trap is non-cleansing. The body part is shaped like a trunk, or box, with a partition across it, dividing it into two unequal compartments for holding water in each, as shown at A and B. An opening is made in the middle, or upper-part, of this partition for the discharges to pass from the inlet-compartment to the outlet-compartment. A dwarfed partition is taken down from the top of the trap, as shown at G, to screen the outlet and to prevent the drain-air escaping. A round, bent-pipe, called the "inlet," is formed in the side of the smaller compartment, as shown at C, for receiving the end of a sink or lavatory waste (or any other such pipe), and this pipe is dipped into the "standing-water" of the trap. The "outlet" of the trap, a round-pipe, is formed at the opposite angle, as shown at D. Provision is made at F for ventilating the drain with which the trap is connected. A large opening over the centre part of the top of the trap is made, as shown in the illustration, for receiving surface drainage, and for allowing any gases which may

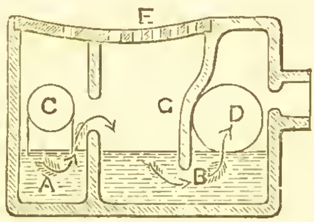


Fig. 46.
"Mansergh" trap, section.

generate in the trap to escape through the grating E. So much for its construction: a word or two will suffice to show that this trap is not only not self-cleansing but that it is dirt-holding. In use it must form itself into a "collecting-box," for there are no less than eight corners for filth to accumulate in; and no amount of water sent through such a trap could scour the parts fouled. The bottom is flat, the sides are vertical, the partition dividing the two compartments is upright, and the area of the surface water of the trap is several times greater than its inlet or its outlet. So that the "standing-water" of the trap, with its decomposing matter, could not get changed by any single flush, nor by many flushes, of water sent through its "inlet." The bad air from this contaminated body of water, if it did not escape through a *waste-pipe* into the house, would at times blow in at the *window*, or door, when near it.

Again, the arrangement of the "inlet" is bad in principle; for it "water-locks" the discharging end of the waste-pipe, instead of allowing it to be exposed to the atmosphere. There is also another evil in connection with this, namely, the waste-pipe (discharging into such a trap) being trapped at its *outlet* end, *i.e.*, the remotest end of the pipe from the sink, or "fitting," would expose the house to any bad air, or decomposing matter left in such a waste-pipe. We saw in our last lecture how foul such pipes get, and we know that every time a little hot water is sent through them what action is

set up by the corrosive matter on the sides of the waste pipes; the vapour coming from this would pass readily through the sink-grating into the house. This trap, therefore, is not the right kind of trap to use for receiving "dirty water" wastes, *i.e.*, from sinks, lavatories, urinals, &c., where such

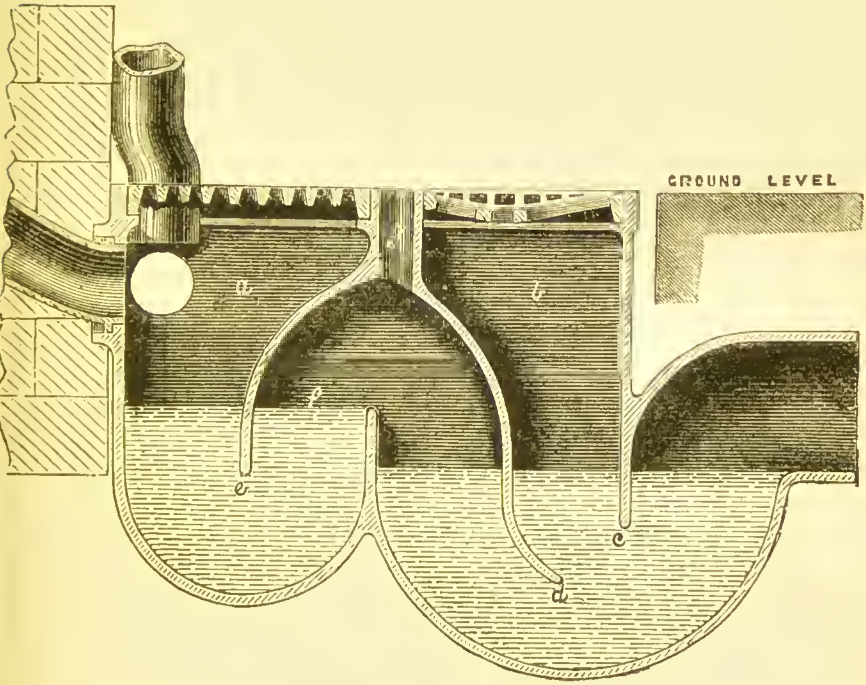


Fig. 47.—Section of the "Triple-dip" trap.

water, remaining stagnant in the trap, would become offensive.*

Fig. 47 shows a trap which I designed some years ago for receiving waste-pipes, and inter- "Triple-dip" Trap.

* If any reader doubts this, let him try the effect of stirring up the water standing in such a trap, and his doubts will soon be removed.

cepting them from the drain. This trap has *three* dips, or air-barriers, to prevent drain-air reaching the ends of any waste-pipes discharging into the waste-receiving compartment. Like the "Mansergh" trap, it has two separate bodies of water. It was specially constructed for receiving waste-pipes from baths and lavatories, when fixed on the bedroom floors, and for protecting them from the drains; and this it most effectually does. It has two important advantages over the "Mansergh" trap. First, it leaves the *end* of any waste-pipe discharging into it *open to the atmosphere*. Second, the *bottom* of the trap is *rounded*, and its configuration makes it easier to cleanse. But this trap is not self-cleansing, *i.e.*, an ordinary flush or flushes of water sent through it will not cleanse it. Now, when a trap cannot be thoroughly cleansed, and all the water standing in it be changed by a good flush of water sent into it, it ought never to be used; and so, though I hold a patent for this trap, *I condemn it* as unfit for use.

Gully Trap.

I have had the well-known *Gully-trap* illustrated at D, Fig. 29, p. 87, because it is now being used for receiving waste-pipes from sinks, &c. And as I do not want plumbers to be "gulled" into its use for such purposes, I have it here to criticise. It may be a good trap for catching detritus, and therefore just the trap to use in yards and streets for surface drainage; but as traps for receiving the discharges from waste-pipes are not

wanted for *catching* (in the sense of holding) anything—not even a "sunbeam," much less decomposing matter—it is not the right kind of trap for sink, urinal, and lavatory wastes, &c. &c. It forms a catch-pit for filth and decomposing matter, and no ordinary flushes of water would cleanse it. It is a non-cleansing trap, and we must therefore put it aside with the rest of the incurables.

Other Traps Non-cleansing.

There are other traps used for disconnecting waste-pipes from drains of a non-cleansing nature, which we have no time to examine; we therefore hasten to consider the much used Drain-syphon for trapping off sewers, &c.

DRAIN-SYPHON.—This trap, illustrated in Fig. 48, being a round-pipe trap, would be self-cleansing if it had no "man-hole," and was provided with

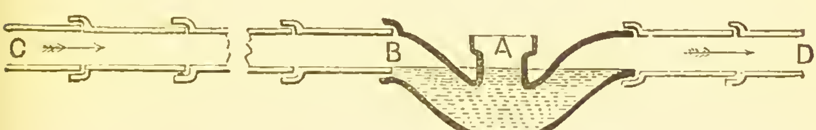


Fig. 48.—Section of a Drain-syphon.

means for a water-fall into it. But, as it is, no pressure of water is (or only very rarely) brought to bear upon the "standing water"* of the trap

* The quantity of water held by an ordinary 6-in. Drain-syphon, with a man-hole in it, as shown in Fig. 48, is about eighteen pints, or just ten pints more than my 6-in. "Ventilating Drain-syphon," Fig. 77.

at B, and consequently it never gets perfectly changed by a flush of water sent into the drain. Then the man-hole, A, forms a collecting-place for filth; and this "inspection-hole," as it is often called, soon needs not only "inspecting," but cleaning; for it quickly gets bunged up with matter which, in floating through the trap, has itself been entrapped. Another evil is its want of ventilation, *i.e.*, it has no provision for ventilating itself or the drain with which it may be connected.

Bad Trapping, bad Drainage.

I have dwelt at length upon the non-cleansing class of traps, and severely criticised those brought before you, as perhaps its worst specimens; because bad trapping means bad drainage. Certainly, good trapping is absolutely necessary to good drainage.

Details perfect.

If we want perfection in the sanitary arrangements of a house, we must pay attention to its *every* detail; for, however well-planned the plumbing and drainage may be, it would not be sanitarily perfect with non-cleansing traps under the "fittings" inside the house, or with filth-collecting traps on the drains outside, *i.e.*, round about the house.

Passage through Traps.

When foul matter is discharged into a trap, with a water-flush after it, it should pass through it, as dreams through the brain, leaving no substance behind. I hope to prove to-night that certain traps do this, and such traps I have called

self-cleansing; but, before experimenting on these, let me lay down the principles on which such traps are constructed, and the conditions on which they should be fixed :—

Principles of Self-cleansing Traps.

(1) The trap should be free from all angles, corners, and places where filth could accumulate.

(2) A free way should be made for the discharges to pass through the trap without breaking their form, *i.e.*, the traps should be like a round pipe, so made or bent as to form a water-seal of about 1½ or 2-ins. deep.

(3) The body of the trap, for fixing in "horizontal" pipes or drains, should be smaller than its inlet, so as to hold as small a quantity of water as possible, consistent with the position in which it will be placed and the work it will have to do, to admit of easy changing every time a flush of water is sent through it.

(4) The minimum-sized* trap should be used consistent with circumstances, but governed to some extent by the size of the waste-pipe or drain on which it is fixed, and the flush of water likely to be sent into it.

(5) The water-way *into* a trap for fixing to flat-bottomed vessels with a grating over its mouth, should be larger than its body part, or than the waste-pipe with which its outlet may be connected,

* A trap, though of a self-cleansing form, may become a little cesspool if the size is greater than can be cleansed by an ordinary flush of water from the "fitting"—washhand basin, sink, or water-closet—on which it is fixed.

so as to be able to send efficient water-flushes through the trap to cleanse it and its waste-pipe. When the trap is smaller than the waste-pipe, no good flushes can be sent through such piping to cleanse it. (See Figs. 49 and 50, showing such traps; or the plumber can easily cone a piece of lead pipe for receiving a larger grating or plug, or

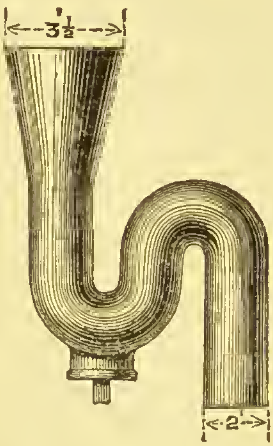


Fig. 49.—2-in. S-trap, with enlarged mouth.

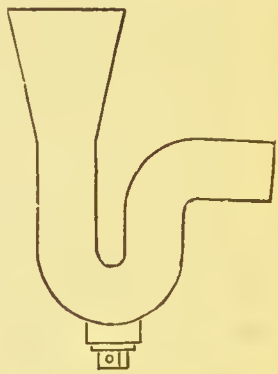


Fig. 50.—2-in. Half-S trap, with enlarged mouth.

washer, and solder this to the inlet of a syphon-trap, as shown at A, Fig. 103, p. 238.)

(6) The inlet, or mouth of the trap, should be so arranged that the water-flushes shall fall upon the "standing-water" of the trap with a vertical pressure, so as to drive everything foreign out of the trap, and to entirely change its previous contents.

(7) The *inlet* side of all traps fixed upon drains outside the house should be *open to the atmosphere*,

so that any bad air rising from foul matter decomposing in the trap, or coming through it from the drain or sewer, may readily pass into the open air, or be largely diluted with fresh air before passing into any waste-pipe, soil-pipe, or drain discharging into such traps. In cold countries, where the water standing in such traps would be liable to freeze in severe frosts, the mouth of the trap should be sealed over, and the "foot-ventilation," or air-induct, should be taken into the waste-pipe, soil-pipe, or drain some little distance away from the "standing-water" of the trap, to prevent the cold air-currents playing upon it and freezing it.* In this country, in sheltered places, there is little or no risk; and if the trap (for disconnecting waste-pipes, soil-pipes, or drains) is kept well down into the ground in exposed places, there is no danger from frosts, though in severe frosts it is well to throw a little straw over the gratings of such traps. During the last severe winter, out of hundreds that I have had fixed, I only heard of one such disconnecting-trap being frozen; and scores of them, from circumstances, have their "standing-water" within 15-ins. of the ground level.

Traps exposed to Frost.

* Another advantage is gained by keeping the air-induct pipe some little distance up (say 15-ins.) from the bottom of a trapped soil or waste-pipe, for when a full and rapid discharge of water is sent into a soil or waste-pipe it does not get away as fast as it enters, but accumulates in the bottom of the pipe, and, rising up in the pipe, would readily flow into the foot-ventilating or air-induct pipe if kept too low down, and perhaps stop it up with foreign matter.

Experiments with Self-cleansing Traps.

Ocular demonstrations that "round-pipe" traps, or "syphon" traps, are self-cleansing, were now given by the model trap arrangement, illustrated in Fig. 51, and explained on p. 135. In order to show the workings of the insides, the traps were made of glass, and a strong light was thrown upon them from a bull's-eye lantern. The following experiments, among others, were made:—

(1) The glass "round-pipe" trap (D, Fig. 51,) was charged with blue-water, and a small flush of clean water was then sent into the trap from the washhand-basin, washing out the blue-water and leaving the trap perfectly clean.

(2) The trap was then filled nearly up to the level of its "standing water" with india-rubber cut into small pieces, and this was completely washed out of the trap by a flush of about three pints of water sent into it from the basin.

(3) The water in the trap was then well coloured with plumbers' soil, and a handful of gravel was also put into the trap; and the whole of it washed out, and the trap left clean, by a small flush of water from the basin.

(4) The trap was also tested with strong soapy water with a like result, *i.e.*, the soapy water was washed out and the trap cleansed by a small flush of clean water from the basin.

D-trap, Non-cleansing.

The small* D-trap with glass cheeks, as used

* Though this trap is so much smaller than the "small" D-traps in use all over the country, and though the "wire-barred"

in a previous lecture, was again tested; but, after several flushings, it remained largely charged with soapy water (Fig. 37, p. 113, illustrates this trap, with its plug-and-washer and washhand-basin), and the figured dimensions on p. 112 will give the reader a clear understanding of the actual thing as experimented with.

TRAP-SYPHONAGE, AND DISPLACEMENT OF WATER IN TRAPS.—The experiments that we have just made clearly prove that while some traps are non-cleansing, others are self-cleansing. But "self-cleansing" traps—*i.e.*, round-pipe traps—are *syphoning* traps, and especially when they have long vertical lengths of piping attached to them—the

plug-and-washer is larger than that generally used—having an inch clear way in its "lining"—the "standing-water" of the trap (as tested with soapy water, water coloured with stone-blue, and plumbers' soil) could not be entirely changed by a single, nor by many discharges of clean water sent through the trap from the washhand-basin. What a *new* form of D-trap may be made to do, as explained on page 115, is not the question; the trap under criticism here is the D-trap as used up to the present time.

It was unfortunate that the distance between the bottom of the basin and the "standing-water" of the trap was not the same in the D-trap as in the glass "round-pipe" trap, for the extra length of the dip-pipe in the latter told in its favour. But, after the close of the lecture, on the re-delivery night, the dip-pipe of the glass round pipe trap was shortened, and made *less in length than that of the D-trap*, and the experiments were repeated with it with the like results—that is, a perfect cleansing out of the round-pipe trap by a small flush of water from its basin. If any man doubts the self-cleansing nature of the syphon, *i.e.*, a *round-pipe* trap, and believes in the sanitariness of the D-trap, let him try the traps with soapy water, under precisely similar circumstances, and he will soon satisfy himself on the wholesomeness of the one, and the unwholesomeness of the other.

longer the leg the greater is the syphonage. They are often called "syphons"—and they are this—and, unless such syphonage can be prevented, to use such traps would not only be useless but dangerous. Let me give some experiments to show how, in practice, traps are often unsyphoned —that is to say, unsealed.

A series of experiments were here made to show how in practice traps were often unsyphoned by discharges sent through them, or through the waste-pipe or soil-pipe on which they were fixed.

Testing Arrangement.

An arrangement* for testing trap-syphonage, and for other experiments, was fitted up on a stand, as illustrated in Fig. 51. A represents a model bath fixed on a chamber floor, and B a lavatory basin on a ground floor. Inch *glass* syphon, or round-pipe traps half-S, were fixed under the bath and lavatory, as shown at G and D, with inch lead branch-wastes from them into the main waste-pipe, H. The waste-pipe was continued up for ventilation, as shown at J, and it was left open at its discharging end, where for convenience it was made to discharge into a R.W. head outside the Hall. An inch lead air-pipe was taken out of the lowest trap, and continued up above the highest, and branched into the air-pipe of the waste-pipe,

* Though this model bath and lavatory arrangement was, for convenience, fitted up on a smaller scale than that which generally obtains in practice, the results were just the same as those which actually occur under similar treatment, viz., a syphoning out of the water in unventilated traps, and a non-syphoning in ventilated traps (see results of experiments with full-sized fittings, pp. 144–152).

receiving the branch air-pipe from the bath trap on its way up, as shown in the illustration Fig. 51. Stop-cocks were fixed in the air-pipes from the

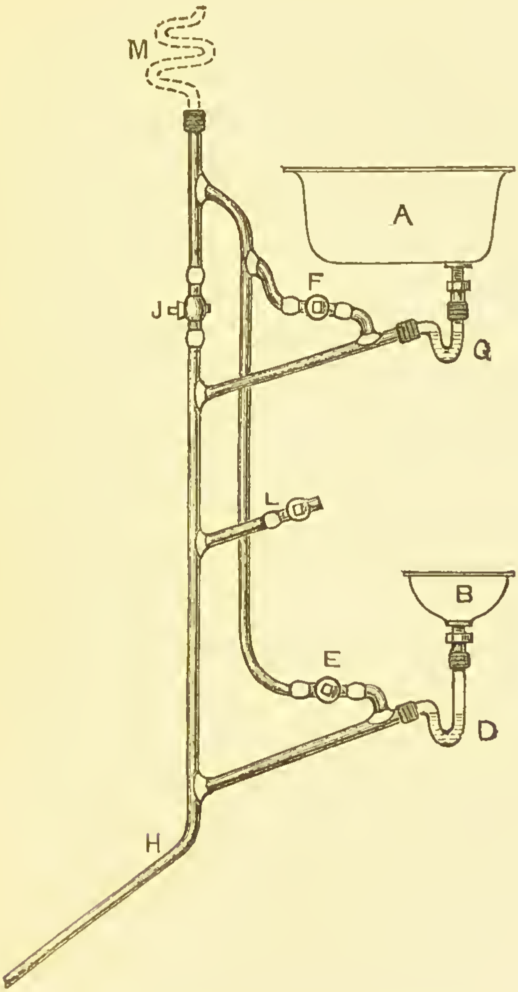


Fig. 51.—View of model used for testing traps and syphonage.

traps, as shown at E and F, for controlling the ventilation during the experiments. A stop-cock was also fixed in the air-pipe on the top of the

main waste, as shown at J, for shutting off the ventilation at this point when so wanted.

Experiments with unventilated Traps.

Among other experiments, the following were made, all the stop-cocks (E, F, and J, Fig. 51) being shut off to stop the ventilation, except that the discharging end of the waste-pipe H was left open. (1) By discharging a small quantity of water from the bath A, the lavatory trap D was unsealed. (2) By discharging a basinful of water from the lavatory B, the bath trap G, above, was similarly unsealed. (3) By discharging a small quantity of water out of the bath, and suddenly shutting off the waste-valve, both traps, D and G, were unsealed. (4) By discharging a basinful of water from the lavatory,* B, both the upper trap G, and lower trap D, were unsealed.

The main waste-pipe H was then ventilated by opening the stop-cock J; and, though it prevented the bath trap G from being unsyphoned by a discharge from the lavatory, it did not prevent the syphonage of the trap D, through which the discharge was sent. Nor did it prevent the syphonage in either trap in a discharge of water from the bath, as proved by one or two tests.† It should

* In plug-basins, when no overflow-pipe enters the dip of the trap to give it vent, the water can be held up in the dip in suspension by a quick replacement of the plug, and by this means the trap may be made to retain its seal, even though the discharge through it may have unsyphoned all the other traps fixed on the same waste-pipe (see experiment, p. 172).

† These experiments prove that those who depend upon the ventilation of the main pipe only, be it a soil or waste pipe, depend upon means inadequate for the protection of a house from bad air;

be borne in mind that the waste-pipe was open at both ends, top and bottom.

The foregoing experiments proved that two traps fixed on one pipe, like two negatives in a sentence, destroy each other.

Some experiments were then made with the D-trap B, Fig. 37; the "Bower" trap, Fig. 52; and the "Eclipse" trap, Fig. 43, to show that though these traps were not unsyphoned with the ease with which "round-pipe-traps" were, they were by no means proof against the action of discharges sent through them, or through the main pipes into which they may be branched. Experiments with the

(1) The small glass-cheeked D-trap, illustrated at B, Fig. 37, was fixed at L, Fig. 51, and soapy water was put into it. With the ventilating-cocks, E, F, J, Fig. 51, turned off—to prevent ventilation—and a discharge of water sent out of the bath A, the water in the D-trap was kept in a *very agitated state* during the whole time the discharge was passing through the main-waste H; and, by the time that seven or eight gallons of water had passed out of the bath, the water in the D-trap had been lowered half-an-inch, *i.e.*, the water had been syphoned out of the trap enough to reduce its "seal" to about half its normal depth. D-trap.

(2) The "Bower" trap, $1\frac{1}{2}$-in., Fig. 52, was The "Bower."

or, as clearly shown, an air pipe on the main-pipe, though of the same size, is insufficient to prevent round-pipe traps, and self-cleansing traps, from being unsyphoned, where large bodies of water are sent through the main piping.

then fixed in lieu of the D-trap, at L, Fig. 51, and the effect upon this trap was even greater than that upon the D-trap.

and "Eclipse."

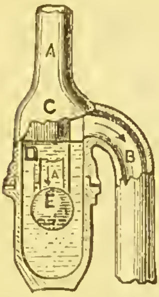


Fig. 52-"Bower" trap.

(3) The "Eclipse" trap, $1\frac{1}{2}$-in.—the *large* size of which is illustrated in Fig. 43—was then fixed in place of the "Bower" at L, but before half-a-dozen gallons of water had passed through the main waste-pipe from the bath this trap had lost more than three-fourths of its seal, and after discharging a few gallons more the trap was practically unsyphoned, for, though the dip-pipe stood a trifle under the water, the smallest vibration broke the seal.

Results.

These experiments prove that, like syphon traps, *all* traps require ventilation, at any rate under certain conditions; for if all the traps tested did not become quite *unsealed*,* their "seals" were reduced to a very easy breaking-point, and the water in them was stirred up so much by want of ventilation that bubbles of air passed into the dip-pipes by almost every discharge from the bath A.

With the air-cock J open, *i.e.*, with the main waste, H, ventilated at top bottom, I have proved, by the same apparatus, that all traps require ventilating, apart from the ventilation of the main-pipe.

I have thus shown that *round-pipe* traps—that is

* The syphoning action would be greater in a longer length of waste piping.

to say, "self-cleansing" traps—easily syphon themselves, and are easily syphoned by others fixed in connection with them. I need hardly say to practical plumbers that, unless such syphonage can be perfectly remedied, such traps are worse than useless; for while they would impede the cleansing force of the discharges through the waste-pipes, they would be of no protection to the house.

By these experiments I have also proved that if absolute safety is wanted, the "Eclipse" trap, the "Bower" trap, and even the D-trap—which is equivalent to saying that *all* traps—must be ventilated.

In my book, "Dulce Domum," I have explained the action upon traps of discharges sent through a waste-pipe or soil-pipe; and shown how to prevent one trap acting upon another, or upon itself; in other words, I have explained the proper method of ventilating traps. We shall therefore, to-night, give some experiments to prove that what is there said on this is absolutely correct, and show you by one or two severe tests that trap-syphonage is prevented by trap-ventilation.

Action upon Traps; *vide.* "Dulce Domum."

In the model bath and lavatory arrangement for experimenting with, an air-pipe was taken from the branch waste to the lowest trap, as illustrated in Fig. 51, and continued up above the highest trap, and branched into the main waste or air-pipe. Into this ascending air-pipe, from the lower trap, the branch air-pipe from the upper trap was taken,

Experiments with Traps Ventilated.

so that each trap was properly ventilated. The stop-cocks E and F (which had been shut during the former experiments) were then opened, giving the traps ventilation, when the water was left undisturbed, or if disturbed, it was only very slightly in either trap, notwithstanding that full and rapid flushes were sent through the waste-pipe H. I give here the results of some of the experiments made :—

(1) A large body of water was sent out of the bath A, sufficient to charge the whole length of the waste-piping H, but it did not affect the water in the lavatory trap D.

(2) The washhand-basin B was then filled with water and rapidly discharged (through an inch clear way "lining" of the plug connection), but it did not affect the water in the bath-trap G, above, in the slightest degree.

(3) The above-mentioned experiments were then made over again with the air-cock J shut, but this made no appreciable difference so long as the trap-ventilation remained perfect.

These experiments were several times repeated, but always with the same result, that is to say, no discharge of water sent through the waste-pipe H from the bath or lavatory could unseal either the working trap or the idle trap when the branch wastes were ventilated, clearly establishing the fact that efficient trap-ventilation prevents trap-syphonage.

Ignorance on Ventilation.

A great deal of ignorance prevails on this question of ventilation, and that, too, among men who fancy they know all about it. As a proof of this, many simply ventilate the *main* waste-pipe, or *main* soil-pipe, but do not ventilate the *branches* upon them. They insist upon the main soil-pipe being carried up full-size to the open air, and in some cases are willing to give it foot-ventilation, but they are satisfied with this. Now I hope all here are convinced that no stack of waste-pipe, or soil-pipe, is properly ventilated which is not only exposed to the atmosphere at both ends, but unless, in addition, it has each individual branch ventilated, and especially where large bodies of water are likely to be sent through the main piping.

I was amused some time ago in reading some remarks on the "bends" of a ventilating-pipe to a soil-pipe, written by a gentleman who had been called on to give a report on some plumbing. He found two or three bends in the 4-in. ventilating-pipe of the soil-pipe, and he wrote that the pipe ought to have been carried up "*straight.*" A ventilating-pipe cannot be fixed without something to fix it to. It will not stand like a flag-staff or a scaffold-pole, fixed or secured only at its foot. If this gentleman had had more experience, he would have known that bends in such pipes, when they are made full-bore, make a trifling difference ; at any rate, not enough to write about in a report. I have given elsewhere, in my report

on the value of cowls,* the air-currents through some pipes which are full of bends, and anybody who reads the results will be satisfied that it is better to let an air-pipe follow the lines of the building to a reasonable extent, rather than stick up a hideous pipe like a scaffold-pole, with struts to support it from chimney and parapet. But let me give you a proof! As you see, I have here a pipe† *full* of bends. I will now have it placed on the top of the present air-pipe to the main waste-pipe on which we have just been experimenting. I will send some flushes of water through the piping, and there will be little or no movement of the "standing-water" of the traps, proving that bends, when properly made, do not interfere to any appreciable extent with the working of the traps upon a pipe; nor do they, when made of easy radius and of full-bore, interfere much with the ventilation.

Mr. Teale's Book.

Mr. Pridgin Teale, M.A., surgeon to the General Infirmary of Leeds, has done so much good by his interesting book, entitled "Dangers to Health," that I hesitate to refer to it in any way disparagingly; but duty compels a criticism.

Mr. Teale rings the alarm-bell vigorously, and paints vivid pictures of the dangers people run by neglecting the proper drainage of their houses; but,

* "The Plumber and Sanitary Houses," pp. 278—350.

† The dotted lines above the letter J, Fig. 51, show the pipe referred to here.

though he shows valuable improvements on old plumbing practice, his method of saving them is not perfect. He sends out a boat which will not hold water, rather than a life-boat; for by his arrangement the water would be syphoned out of the traps, and then there would be no protection from them. Let me give one example. In the *second plate* in his book, entitled, "House with Faulty Arrangements Avoided," I will show you how one and all of the traps there shown would at times get unsyphoned. By emptying the bath, the lavatory trap C, and the sink trap G, would become unsyphoned, and the air in the waste-pipe would find an easy access through them into the house. Again, by discharging the lavatory, the sink-trap and the bath-trap would get unsealed.

Then, as you see, even the main waste-pipe is not ventilated; for cutting off the pipe at the discharging end, and exposing that to the atmosphere, is not *ventilating* it, any more than an air-pipe only at the top and the end trapped at the bottom; in fact, not so much, for the gases thrown off by matter adhering to the sides of a waste-pipe are more likely to ascend than descend.

I will not criticise the detail arrangement, though that is important; and would not have brought this before you but that waste-pipes are being fixed pretty freely, as shown in this diagram; *i.e.*, long lengths of waste-pipe are fixed without trap ventilation, so that others as well as Mr. Teale have fallen into the same error.

Trap Ventilation Important.

As trap-ventilation is so important to prevent traps from becoming air-inlets, I will give you the results of some important experiments made a month or two ago, when testing the capabilities of waste-pipes and traps. It would take an entire evening to give the result of each test, and to explain the various modes adopted, but with the aid of the illustrations it will not take long to put you in possession of the facts gained by some of the experiments.

Experiments with Traps on $1\frac{1}{2}$-in. Waste-pipes.

That these may be better understood, I have had the testing arrangements illustrated; and as they are drawn to a scale, a clear idea of the actual sizes of the pipes and fittings can readily be formed. The traps in each case were fitted up with glass windows in their sides for taking observation.

Fig. 53, Plate 2, represents a stack of $1\frac{1}{2}$-in. lead waste-pipe, fixed in a house to take the discharges from three slop-sinks—one each on chamber floor, second floor, and third floor. Beard and Dent's patent cast lead traps, $1\frac{1}{2}$ in., were fixed, as shown, under the sinks A, B, and C, with $1\frac{1}{2}$-in. branch-wastes from them into the main waste D.

A pailful of water thrown down sink A, sucked three-fourths of an inch of water out of traps B and C. Another pailful practically unsealed them. A pailful of water thrown down sink A, with the air-pipe E stopped up, sucked an inch of water

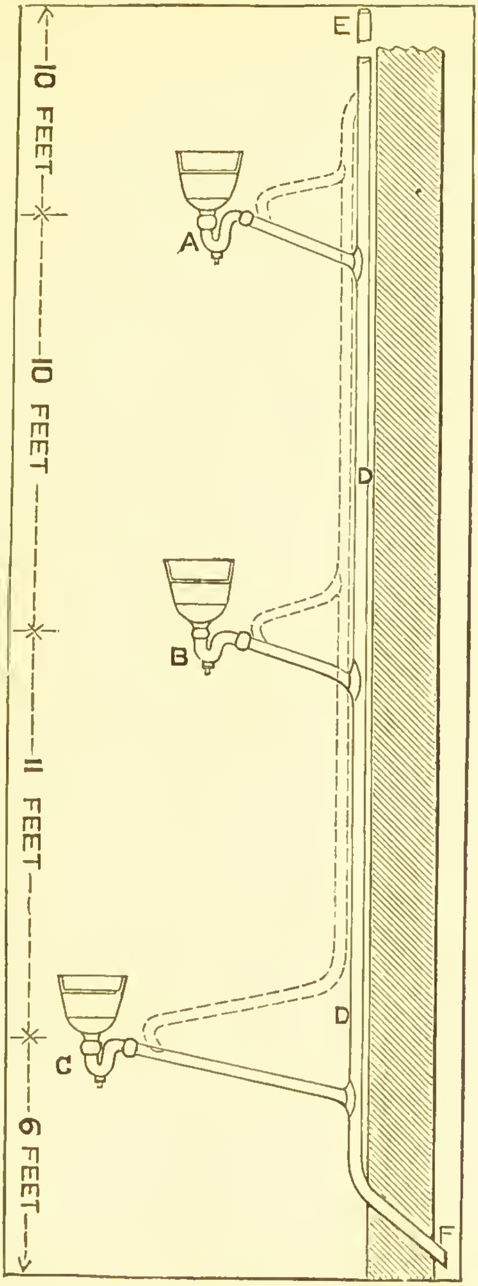


Fig. 53.—Section of a stack of Waste-pipe, with three Slop-sinks upon it, as used for testing Syphonage of "round-pipe" traps.

out of each trap, and practically untrapped itself—sink A.

A pailful of water thrown down sink B, with the air-pipe E stopped up, pulled an inch of water out of traps A and C. Another pailful unsyphoned them.

These traps were then ventilated by taking a $1\frac{1}{2}$-in. lead pipe (the same size as the waste) from the lowest branch, and continuing it up and connecting it with the air-pipe of the main waste above the highest trap, and branching $1\frac{1}{2}$-in. air-pipes from the other traps into it, on its way up. Three pailfuls of water (stable pails, holding about three gallons) were then thrown down sink A in rapid succession, but, though there was a little movement of the "standing-water" in traps C and B, not $\frac{1}{16}$th of an inch was drawn out of either, and its own trap was left fully charged with water.

Ditto, with larger Pipes.

Similar tests were made with a *larger* waste pipe. Instead of the $1\frac{1}{2}$-in. piping, 2-in. piping was used for the main waste, and also for the branches from the sinks, and 2-in. traps, with enlarged mouths (as illustrated in Fig. 50), were fixed under the sinks.

A pailful of water was thrown down sink A, Fig. 53, and this discharge sucked an inch of water out of traps B and C, and nearly untrapped itself. Another pailful quite uncharged, *i.e.*, untrapped, the two lower traps, and nearly its own. The

air-pipe E was stopped up in each of these two trials, but with this air-pipe open it made little difference to the *lower* traps, though it was helpful in preventing the *top* trap from being unsyphoned.

With a trap formed in the pipe at F (the air-pipe E being open to the atmosphere), and a pailful of water thrown down sink A, air was forced out through the trap C, and some of the "standing-water" of the trap was sent a foot or 18-in. up into the sink. At the same time the sink-trap B was more than half unsealed.

These trials were all made over again, with the branch to each trap ventilated, and though several pailfuls of water were thrown down in the latter tests, no appreciable effect was made on the traps, not even with a trap formed in the main waste-pipe at F.

Tests with Bath Waste.

Fig. 54 shows a bath, and a lavatory, discharging into one main pipe, at different levels; and (without the dotted lines, showing *how* such pipes *should* be ventilated) it is a fair representation of how waste-pipes are fixed even in these enlightened days, except perhaps that the waste-pipe here—$1\frac{1}{2}$-in.—is smaller than that generally used.

A bath is fixed on the chamber floor with $1\frac{1}{2}$-in. waste-pipe from it to discharge in the open air. The waste-pipe from a lavatory on the ground floor is branched into this bath waste. I have shown an air-pipe, K, on the top of the main waste, as in the

tests which I made there was one, but many people never even fix this air-pipe—they are satisfied if the pipe is open to the air at its discharging end. Let us see the result of the tests.

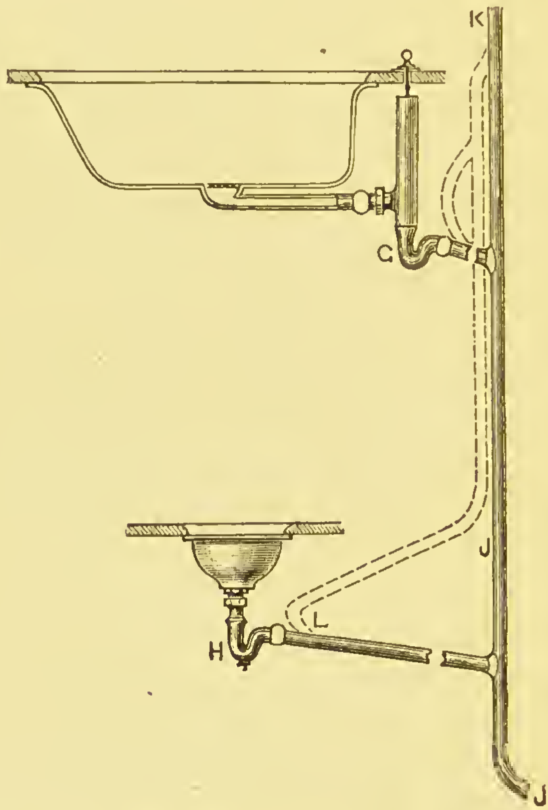


Fig. 54.—View of bath and lavatory waste, as used for testing trap-syphonage.

With the air-pipe K open to the atmosphere, and the end of the waste-pipe J open also, the water in the lavatory trap H was not only syphoned out by the emptying of a bath of water containing about fifty gallons, but 130 feet (lineal)

of air was drawn through it into the waste-piping, as registered by an anemometer fixed over the mouth of the trap H.

Another test was made exactly as the last—but with a "Bower" trap (Fig. 52) fixed at H, instead of the 1½-in. "patent cast lead trap." During the discharge, the india-rubber ball did not keep its seating for three seconds together; the water in the trap was kept in a very agitated state all the time, and 110 feet (lineal) of air was drawn through the Bower trap, as noted by an anemometer. Directly the discharge ceased the ball regained its seating; and, on measurement, though a good drop of water had been syphoned out of the trap, it had still a ½-in. seal, but this test proved that this trap also requires ventilation.

With 1½-in. air-pipe fixed on the branch to the trap at L, and made good into the air-pipe K, as shown by the dotted lines, not a movement was caused in the fan of the anemometer, which was placed over the mouth of the trap H, as before; nor was the "standing-water" of this trap or the bath-trap affected by a discharge of a bath of fifty gallons of water in 2½ minutes.

An air-pipe on the "Bower trap" also prevented any action upon it by discharges through the waste-pipe J. With the trap H moved back into the room, 12 feet away from the main waste-pipe, the result was just the same, *i.e.*, it was unsealed without ventilation; but with ventilation the water remained in the trap intact.

Results of Further Experiments.

In Fig. 55, Plate III., I show another arrangement, and will now give the results of some of the tests made with it.

It represents a stack of 2-in. waste-pipe, with a bath and two slop-sinks upon it. There are four traps on the middle branch—to see the effect upon each during a discharge through the main waste-pipe.

Each trap had a glass side or window in it for making observations.

A 2-in. "patent cast lead trap" was fixed under the bath, and each of the two sinks with 2-in. lead branches into the main waste-pipe. A 4-in. trap was fixed at T, $1\frac{1}{2}$-in. at V, and $1\frac{1}{4}$-in. at U, as shown in the illustration.

Trap-ventilation was fixed, as shown by the dotted lines, *i.e.*, a 2-in. air ascending-pipe was taken off the branch to the lowest trap, and continued up and branched into the main air-pipe above the highest trap, with branches from each trap connected with it on its way up. This ventilating pipe was only used when so wanted, and was under the control of stop-cocks, fixed at R and S.

The first experiment was made *without* trap-ventilation. The bath-cock was opened, and the bath discharged, but before one-quarter of its contents had passed through the waste-pipe, traps P, Q, U, and V were unsyphoned (*i.e.*, unsealed), and three-quarters of an inch of water-seal pulled out of the 4-in. trap T. But as the unsyphoned traps

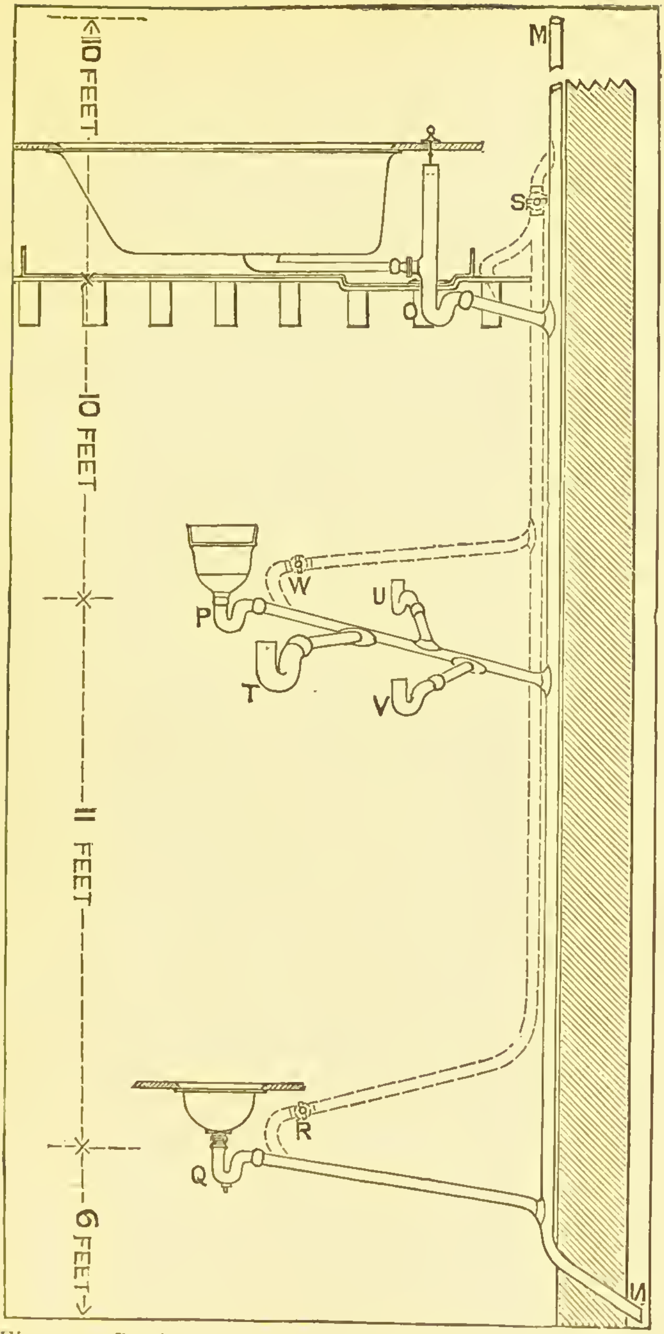


Fig. 55.—Section of a stack of Waste-pipe, with several traps upon it, as used for testing Trap-syphonage.

gave air to the branch-waste, on which this trap was fixed, no more water was drawn out of it by the rest of the discharge.

The same experiment was repeated, but *with* the trap-ventilation perfect, as shown by the dotted lines, and though sixty gallons of water was sent out of the bath, and through the waste-pipe in 2¼ minutes, not one of the traps was unsyphoned. During the greater part of the time the bath was emptying, the water stood up from an inch to two inches in the dip, or inlet, of each trap—P, T, U, V, and Q—but directly the bath was empty the water returned to its normal level. There was no oscillation of the water in any of the traps, and on measurement it was found that trap U was the only one that had lost any water, and this trap had only lost ⅛th of an inch, if quite so much, leaving it with a perfect seal.

Many other tests were made. Pailfuls of water were thrown down sinks Q and P, and the upper and lower traps unsealed by such discharges, with the trap-ventilation shut off by the stop-cocks, R, O, S; but with each branch ventilated the "standing-water" in the traps remained intact, notwithstanding the severe trials to which they were subjected.

ll Traps ust be entilated.

I will not occupy your time with further results of my experiments with traps fixed upon *waste-pipes*, but simply state they all proved that where *tiers* of traps, of any description, are fixed upon

one *stack* of piping, for receiving discharges from slop-sinks, baths, and "quick-waste" lavatories, &c., each individual trap, or branch, must be ventilated, if the traps are to keep their "water-seals" intact.

These tests, made with Beard and Dent's "patent cast lead traps" ($1\frac{1}{2}$-in. and 2-in., both S

Shape of Round-Pipe Trap.

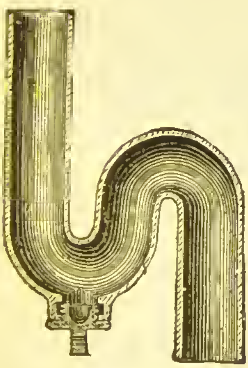


Fig. 56.—Section of S-Trap.

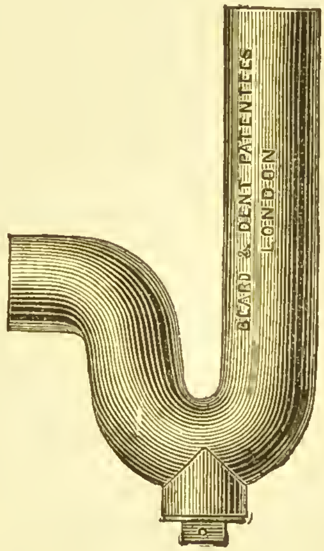


Fig. 57.—View of Half-S-Trap.

and half-S shaped, as Figs. 56 and 57), also established the fact that *round-pipe* traps, when properly ventilated, as shown in Fig. 70, and properly shaped—that is U-shaped in the water-holding part of the trap, *e.g.*, as Figs. 56, 57, and 59—are perfectly free from any injurious effects from syphonage; *i.e.*, such traps will maintain their "seals" in any treatment they are likely to receive

in practice; for if they could not be unsyphoned when fixed on pipes of the same diameter as themselves, nor of smaller diameter, they are more certain to hold their seals when fixed on pipes of larger diameter, where the friction, and therefore the suction power of a corresponding discharge of water, would be so much less. But though U-shaped round-pipe traps (as Figs. 56, 57, and 59) hold their seals securely enough when ventilated,

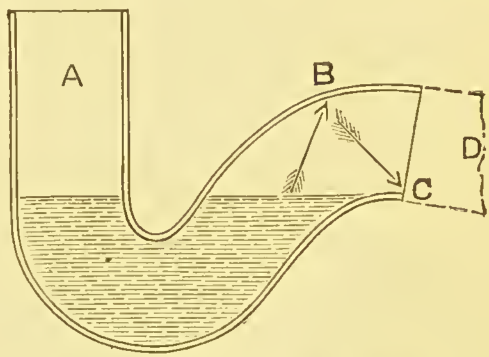


Fig. 58.—Section, Trap Badly Shaped.

round-pipe traps having an *easy rise* to their outlets, as Fig. 58, which is a section of Beard and Dent's 4-in. "P-trap," will not under certain conditions. When, for instance, such a trap is fixed under a *valve*-closet, and the basin is filled with water up to the brim, or nearly so, and discharged quickly by a *sharp* pull of the closet handle, the water falls in a column through the space A, between the basin and the water of the trap, and strikes the "standing-water" of the trap with such force that where a too easy passage-way exists, as

in trap Fig. 58, the contents of the trap are not only *forced* out (in itself a merit), but the water, falling from the basin in a column, and with so much pressure, rushes through the trap, leaving insufficient behind to re-charge it, except where a proper service of water is laid on to the closet to pass through with the discharge in a more broken form. But this is not the case with round-pipe traps having a "vertical" rise to their outlets. The

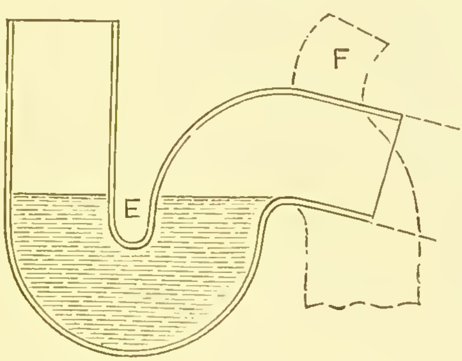


Fig. 59.—Section, Trap Rightly Shaped.

water, when discharged with some force into such a trap as Fig. 58, strikes against the too-sloping side B, and then glancing off, as a ball would, to C—as shown by the arrows—runs away through the soil-pipe D; but in a trap shaped as Figs. 56, 57, and 59 the water would have no such sloping side to glance off from, but, rising vertically out of the trap, would strike against the dome of the outgo, and partly fall back again into the trap and re-charge it, unless at the same moment a syphoning action was set up by the passage of the dis-

charge through the soil-pipe, through inefficient ventilation. The plumber can easily boss back the neck of a round-pipe trap when the way to the outlet is too easy—though, of course, all traps should be perfect in themselves.

"Mansion" Trap.

Knowing the strain upon the *seal* of a trap when fixed under a valve-closet, especially with certain usages (as, for instance, when the basin of the closet is filled up to the brim with a pailful of slops and discharged with great force into the trap), I nowhere in my book, "The Plumber and Sanitary Houses," show a *round-pipe* trap fixed under a *valve-closet*. In the first edition of that book I show a "Mansion" trap (illustrated in Fig. 60) under each "fixed" valve-closet; and as I had improved this trap before the publication of the second edition, I showed, in the Appendix of the later edition, my patent cast-lead "V-dip," or "Anti-D-trap," instead of the "Mansion" trap.

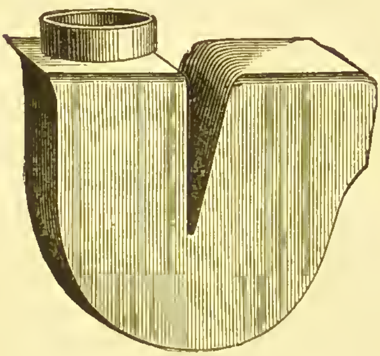


Fig. 60.—"Mansion" Trap.

"Anti-D-Trap."

Referring to this "Anti-D-trap" at the Lectures, I said, "as it was my own design I would say nothing about it, but leave it to take care of itself." As, however, a controversy on traps has grown out of

what I said on traps, I will say something about this trap here. The "Anti-D-trap" is made in *two* sizes for fixing under water-closets, &c. The *large* size is shown in Figs. 61 and 62, and is intended for fixing to water-closets in hotels and public buildings, where it is likely to receive all sorts of things. The *small* size is shown in Figs. 63 and 64, and is specially adapted for fixing to water-closets and slop-sinks, &c., in private houses, or in places where the water-closets are not likely to be treated as

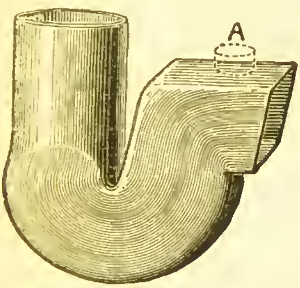


Fig. 61.—View of "Anti-D-Trap," "Large" Size.

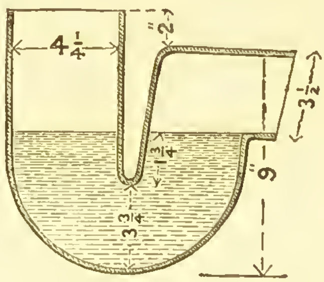


Fig. 62.—Section of "Anti-D-Trap," "Large" Size.

dust-shoots. I admit that the size (Fig. 64) seems small, and I know plumbers will want educating up to the use of it; but it may encourage those who have feeble knees to use it, if they are told that "Anti-D-traps" of *smaller* size than Fig. 64 have been in use for many months, and that no sign of stoppage in them has shown itself. The "Anti-D-trap" placed on the table at the third or fourth lecture was precisely like the one illustrated in Figs. 63 and 64, except that it was ¼-in. *smaller* in diameter in the body part of the trap. This

trap has since been fixed in my factory,* under an "Artisan" closet basin, for the use of a good number of men, and it is working perfectly. To be quite sure on this point of stoppage, I have had a trap made of smaller size than the "small" "Anti-D-trap," Fig. 64, and fixed under a *valve-closet*, for the use of the clerks in my office, and though this trap has been in use many months, it has never stopped up once, and it is as free from

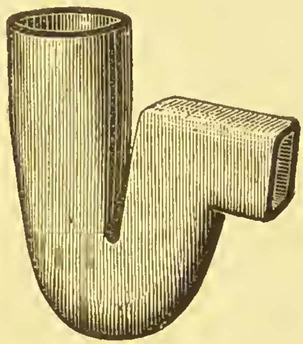


Fig. 63.—View of "Anti-D-Trap," "Small" Size.

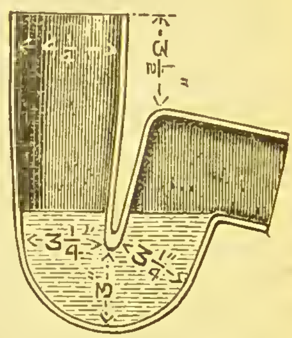


Fig. 64.—Section of "Anti-D-Trap," "Small" Size.

filth to-day as it was after the first day or two's use.

Well, if a smaller trap than the "small" "Anti-D-trap" does not stop up, there can be no risk in fixing the larger size (Fig. 63), and the great advantage gained by its use is worth an imaginary risk of stoppage, for it is the only water-closet trap with which I am acquainted—not excepting even a 4-in. "round-pipe" trap—that will allow its contents to be *entirely changed* with *one* ordinary flush of

* See Fig. 67, Plate V., showing same.

water from a valve-closet. This trap (Figs. 63 and 64) only holds two pints and a half of water, or a little over. Its "seal" cannot be broken, however high a valve-closet may be fixed over it, or however full of water the closet basin may be, nor can it be unsyphoned, where the main pipe is ventilated, by a discharge from a valve-closet, or a pailful of slops thrown down any closet or basin fixed on the same piping, though, as explained elsewhere, the trap, or branch, should be ventilated when other fittings are connected to the same stack.

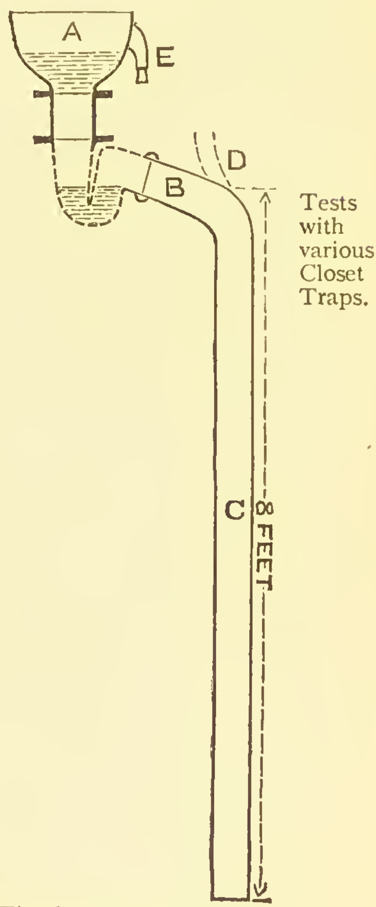


Fig. 65.—View of Valve-closet and Piping for Testing Traps.

As no results of experiments made with water-closet traps were given at the Lectures — though the results given of traps fixed upon *waste-pipes* applied also to traps fixed on *soil-pipes*—I will give here the results of some of the experiments which I have had made during the last two or three months, and many of them are so simple that they can easily be verified.

The arrangement for making the first series of testings is illustrated in Fig. 65, and it is so clear that I need not say a word in explanation.

TABLE (No. 1) SHOWING THE NUMBER OF WATER-FLUSHES REQUIRED TO CLEANSE VARIOUS TRAPS OF CERTAIN MATTERS PUT INTO THEM.

NOTE.—The traps were each fixed in turn under the valve-closet, A, and connected to the 4-in. soil-pipe at B, as shown in the wood-cut, Fig. 65. The basin was filled up to the overflow-arm in each flush (about one gallon of water), and no water was allowed to come into the closet during the time of the discharge.

Quantity of Water in Trap.	Depth of *Dip*, or *Seal*.	Traps Tested.	RESULTS. Matter put into Traps, with number of Flushes to clean same out.			
			Twelve pieces of w.c. Paper, $6\frac{1}{2}$ in. × 5 in.	Six pieces of Paper, and six pieces of short India-rubber Tubing.	Ten pieces of India-rubber Tubing.	Two teaspoonfuls of Ink.
$2\frac{1}{2}$ Pints	$1\frac{5}{8}$-in., *f*.	"Anti-D-Trap," "*Small*" size, Fig. 63	One flush	One flush	One flush	One flush
$5\frac{3}{4}$ Pints	$1\frac{3}{4}$-in., *b*.	,, ,, "*Large*" size, Fig. 61	Two flushes	Two flushes	Two flushes	Two flushes
$6\frac{1}{2}$ Pints	$1\frac{1}{4}$-in.	D-Trap (Pullen's *cast lead*)	Two flushes	Three flushes	Four flushes	Three flushes
5 Pints	$1\frac{1}{4}$-in.	,, "*Narrow-band*," Fig. 40	Three flushes	Three flushes	Three flushes	Three flushes
$4\frac{3}{4}$ Pints	$1\frac{1}{4}$-in.	,, "*Helmet*," Fig. 42	Three flushes	Two flushes	Three flushes	Three flushes
$3\frac{1}{2}$ Pints	1-in., *b*.	"Eclipse" Trap, Fig. 43..................	Two flushes	Two flushes cleared all, except one piece of paper.	Two flushes	Two flushes
$4\frac{1}{2}$ Pints	2-in.	"Round-pipe" Trap, "U-shaped"	One flush	One flush cleared all, except one piece of paper.	One flush cleared all, except one piece of I. R.	One flush

N.B.—With the same matters put into the closet-basin, A, instead of into the traps, it took an *extra* flush in the "self-cleansing" traps, and in the "non-cleansing" traps two extra flushes, to pass the same matters out of the basin and through the trap. With a proper service of water laid on to the closet, and the matters put into the basin instead of into the trap, the results were about the same as (in Table 1) with the matters put into the trap and no water laid on to the basin. The tabulated tests were made without any water laid on to the closet at the time of the discharge, to prevent one trap getting a greater flush than another.

TABLE (No. 2) SHOWING THE LOSS OF *WATER-SEAL* IN TRAPS BY CERTAIN DISCHARGES SENT THROUGH THEM FROM A VALVE-CLOSET.

NOTE.—Each trap was tested in turn, by the arrangement illustrated in Fig. 65,* and no water was allowed to enter the basin at the time of its discharge, for reasons explained in Table No. 1.

Traps Tested.	RESULTS. With $\frac{1}{2}$-in. Air-pipe fixed at D, Fig. 65. Basin filled to Brim, = three gallons.	RESULTS. With $\frac{1}{2}$-in. Air-pipe fixed at D, Fig. 65. Basin filled to Overflow arm, = one gallon.	RESULTS. With 2-in. Air-pipe fixed at D, Fig. 65. Basin filled to Brim.	RESULTS. With 2-in. Air-pipe fixed at D, Fig. 65. Basin filled to Overflow-arm.
Anti-D-Trap, "*Small*" size, Fig. 63......	Untrapped $\frac{1}{4}$-in. below seal.	Left with 1-in. seal.	Left intact.	Left intact.
,, ,, "*Large*" size, Fig. 61......	Untrapped 1-in. below seal.	Left with 1-in. seal.	Water waved out a little—say $\frac{1}{8}$th.	Left intact.
D-Trap (Pullen's *cast-lead*)	Lost *half* its seal.	Left with $1\frac{1}{4}$-in. seal.	Left intact.	Left intact.
,, "*Narrow-band*," Fig. 40	Untrapped, leaving no seal.	Left with $1\frac{1}{8}$-in. seal.	Left intact.	Left intact.
,, "*Helmet*," Fig. 42	Lost 1 in., leaving $\frac{1}{4}$-in. seal.	Lost $\frac{1}{4}$-in., leaving 1-in. seal.	Water waved out $\frac{1}{4}$-in.	Left intact.
"*Eclipse*" Trap, Fig. 43	Untrapped 1-in. below seal.	Practically untrapped.	Left with $\frac{1}{8}$-in. seal.	Left with $\frac{1}{4}$-in. seal.
† "*Round-pipe*" Trap, "U-shaped"......	Untrapped $1\frac{1}{4}$-in. below seal.	Untrapped $\frac{1}{2}$-in. below seal.	Left with $\frac{5}{8}$-in. seal.	Left with $\frac{7}{8}$-in. seal.†

N.B.—Without any air-pipe at all *each* trap was easily unsyphoned, or practically so with the closet-basin, A, filled up to brim, even with this short length of piping (Fig. 65), and the *full-sized* D-trap lost $1\frac{1}{8}$ in. depth of seal at each trial. With a longer length, the syphonage would be greater, but this table is quite sufficient to show that all traps must be ventilated. The syphonage was diminished just in proportion as the air-pipe, at D, was enlarged, for though no results are given here, for want of space, the traps were tested with $\frac{1}{2}$-in., $\frac{3}{4}$-in., 1-in., $1\frac{1}{2}$-in., 2-in., $2\frac{1}{2}$-in., and 3-in. air-pipes, fixed at D, as in the tests given in the table, with $\frac{1}{2}$-in. and 2-in. air-pipes.

MEM.—With a trap fixed at the foot of the soil-pipe (without foot ventilation) the water is not lowered quite so much in the trap fixed under the water-closet.

* Tests were also made on 3-in. soil-pipes, instead of 4-in., but the results were practically the same, though the syphonage was somewhat greater, as will readily be understood, but ventilation easily stopped it.

† With a 2-in. air-pipe fixed on the *outgo* of this trap, as shown in Fig. 65, it could not be unsyphoned, nor could the seal be reduced so readily as with the air-pipe fixed at D.

L

Testing of Traps on Tiers.

With the arrangement illustrated in Fig. 66, Plate IV., another series of testings with closet-traps was made. A stack of $3\frac{1}{2}$-in. soil-pipe was fixed as shown, and a "narrow-band" D-trap (Fig. 40) was fixed at B, a full-sized cast lead D-trap at C, and an "Eclipse" trap at D. A trap was fixed at the foot of the soil-pipe, at E. In some of the testings the main pipe was opened to the air, both at top and bottom, but when this is done it is so stated. A Wedgwood ware valve-closet basin, A, was fixed directly over the upper trap, as shown, and the contents of the basin discharged by means of a basin-plug placed over its outlet.

Test 1.—By discharging a basinful of water quickly (and sealing over the outlet directly the discharge had completed its effect upon the working trap, so that the further effect of the discharge—through the main pipe—might be thrown upon the idle traps), the "Narrow-band" D-trap, at B, was *unsyphoned*, so much so that the water was left three-eighths of an inch below its dip-pipe; the cast-lead D-trap, at C, lost *three-fourths* of its seal, by syphonage; and the "Eclipse" trap, at D, had some of its water blown out (to the height of three or four feet) on to the floor, causing it to lose more than one-third of its seal.

Test 2.—With the "small" size "Anti-D-trap," Fig. 63, fixed at B, instead of the "Narrow-band" D-trap, the result, in a similar trial, was just the same as in Test 1, except that the water in this trap was left one-eighth of an inch lower.

Test 3.—With a full-sized cast-lead D-trap fixed at B, and the "Narrow-band" D-trap at C, a discharge from the basin A, as before, *forced* water out of the "Eclipse" trap, reducing its seal one-third; practically *unsyphoned* the "Narrow-band" D-trap; and syphoned enough water out of the full-sized D-trap to rob it of more than half its seal. The water would have been syphoned out of this "full-sized" D-trap still more if the sides had withstood the syphoning action better; but the withdrawal of the air from its inside caused the top and sides to be pressed or drawn inwards, and this broke the piece of glass in its side (for making observations), and allowed the air to pass through it to fill the partial vacuum, and at the same time to break the syphoning action of the discharge.

The positions of the various traps were changed, and it was found, by a series of similar trials to those already given, that while the *full-sized* D-trap withstood the action of *syphonage* better than any other closet trap (and this I suppose everybody has known for years), the "Anti-D-trap" was less easily* *forced* than any other trap fixed at D. But the various experiments proved clearly enough that every trap, or branch from it, requires ventilation in addition to the main pipe.

Another series of trials was made with the

* It took *ten* discharges to force the water out of the "Anti-D-trap" (fixed at D) below the seal, but it only took four discharges to unseal some of the other traps.

main soil-pipe open to the air full bore, at top and bottom, with the results as follows, viz.:—

Test 1A.—With the "small" "Anti-D-trap" fixed at C, and the basin, A, filled with water and discharged *ten* times, the water is lowered about three-quarters of an inch, leaving the trap at the end of the ten discharges with 1 in. seal.

Test 2A.—With a "Narrow-band" D-trap fixed in the same position, at C, and a similar number of tests, it lost a little over three-eighths of an inch, leaving it with $\frac{7}{8}$ in. seal.

Another series of experiments were made with the small bath used at the lectures (A, Fig. 51), instead of the closet basin, and this bath was fixed over a 4-in. "round-pipe" trap fixed at B (Fig. 66). The bath was discharged by means of a basin-plug fixed over its outlet.

Test 1B.—In two discharges from this bath, the "Narrow-band" D-trap, fixed at C, lost *three-fourths* of its seal, notwithstanding that a 2-in. air-pipe was fixed at F. During the whole of the time the discharge from the bath was passing through the main soil-pipe, the water in this trap was drawn away from its dip-pipe, and air passed through it to the soil-pipe very freely.

Test 2B.—The "small" "Anti-D-trap" was then fixed instead of the "Narrow-band" D-trap, and subjected to the same test, and the result was that it was left with $\frac{1}{8}$ in. less seal than the other trap.

Test 3B.—Beard and Dent's 4-in. P-trap (Fig. 58) was then fixed at C, and this trap was readily un-

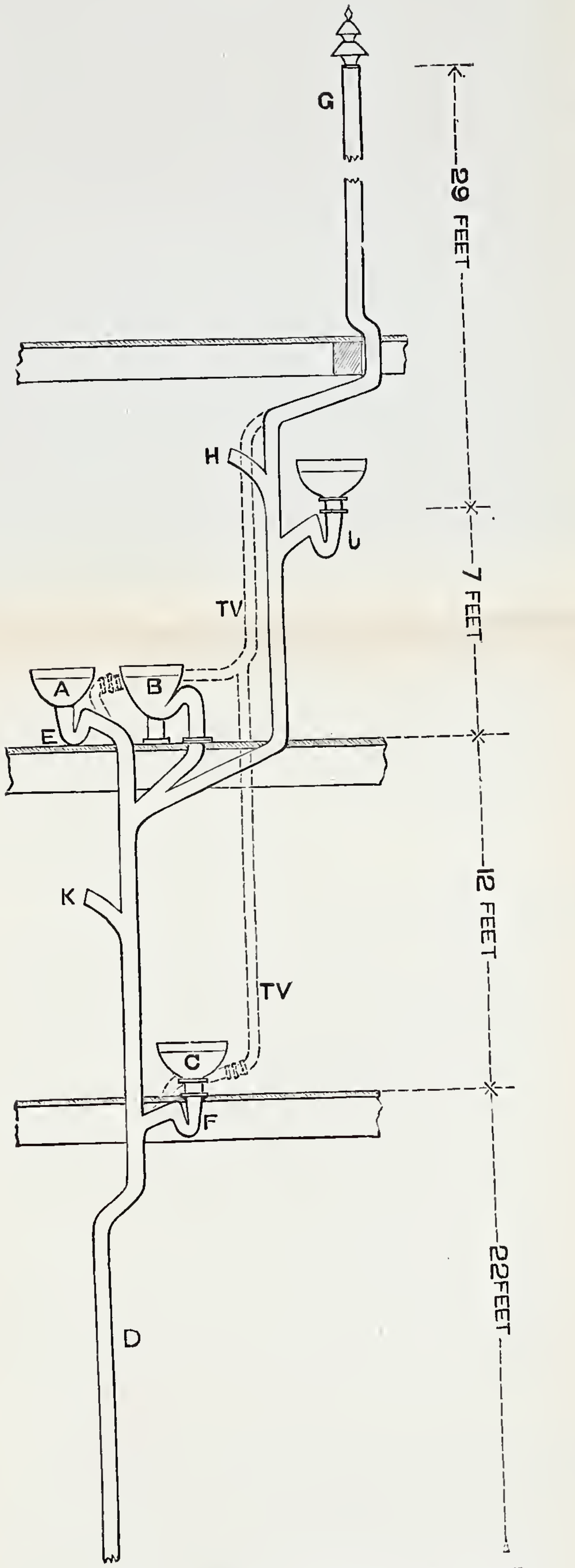


Fig. 67.—Section of a *stack* of 3 in. Soil-pipe, with three Water-closets upon it, as fixed in our factory for the use of our employés, and for testing trap-syphonage. See pp. 165-168.

Note 1.—The bends in the main air-pipe are shown too sharp, and the connection of the branch to closet B is imperfectly shown.

Note 2.—Stop-cocks are fixed in the air-escape pipe, TV, as shown by the dotted lines, for shutting off the ventilation of the traps.

syphoned without an air-pipe on its branch; but with the trap ventilated by a 2-in. air-pipe, it could not be unsyphoned by any discharges from the bath, fixed as before over the upper trap.

An entire book could be filled with the results of various experiments made with traps, but I have only space here to mention a few more.

Testings of Closet Traps on 3-in. Pipes.

Fig. 67, Plate V., represents a stack of 3-in. lead soil-pipe, which I had fixed some months ago, with three water-closets upon it, for the use of the people in my factory. The pipe was fixed of this small size to test its capabilities, and I may say here that it has never shown the least sign of stoppage, though the two upper closets are used by about thirty people daily, and some days by a *much larger* number. An "Artisan" closet basin is fixed, at A, on the second floor of the warehouse, with an "Anti-D-trap"* (of *smaller* size than Fig. 64) under it. Adjoining this closet, a "Vortex" closet is fixed, as shown at B. On the floor below a valve-closet is fixed, as shown at C, for the use of ten or more clerks, and under this closet, at F, is another "Anti-D-trap" of smaller size than Fig. 64. Stumps are fixed at H, J, and K, for fixing traps, &c., upon them for making experiments. The branches to the water-closet traps are ventilated by a 2-in. lead air-pipe, as shown, but this trap ventilation is under the control of stop-cocks, for making experiments with or

* This identical trap was placed on the table at one of the lectures.

without the ventilation of the traps. A small angle cistern with syphon arrangement for giving a two-gallon flush of water is fixed over the "Artisan" closet; a "sluice" apparatus is fixed over the "Vortex" closet; and the valve-closet is supplied by means of a valve and regulator attached to the apparatus.

Tests of "Anti-D-Traps."

Tests to show the *self-cleansing* nature of the "small" "Anti-D-trap" in practice.

Test 1C.—Twelve pieces of water-closet paper, put into the valve-closet basin, C, are easily sent out of the basin and through the "small" "Anti-D-trap," F, under it, with one pull of the closet handle—*i.e.*, with the handle pulled up as far as it will go, and held there two seconds, or with the handle slowly pulled up and closed, giving only a fair flush of water.

Test 2C.—Ten pieces of India-rubber (5 ps. 1¼ in. dia. 1½-in. long, and 5 ps. 1 in. dia. 1½ in. long) are easily sent out of the closet basin, and through the trap, with one fair flush of water.

Test 3C.—With the water in the basin well-coloured with plumbers' soil, one pull of the handle will clear it out of the basin and trap, leaving not a vestige behind.

Test 4C.—After the closet has been used for the purpose of nature, one fair flush of water, by pulling up the closet handle and slowly closing it, will clear the matter right out of the basin and trap.

Tests for Syphonage

Tests for syphonage of traps on the same arrangement—Fig. 67.

Test 1D.—With the valve-closet basin, C, filled up to brim, and no water allowed to come into it during the time of the discharge without trap-ventilation, but with the main soil-pipe open at top and bottom, the trap is left intact—*i.e.*, with its full seal.

Test 2D.—A pailful of water thrown down either of the water-closets, A and B, will not unsyphon the "small" "Anti-D-trap," F, and that, too, without any ventilation of the trap; and it is left with more than half its seal with five pailfuls of water thrown down the above closets in succession.*

A valve-closet, with an "Anti-D-trap" under it, was fixed on the branch H, and some tests made with traps fixed on the branches J and K; the outlets of the closets, A and B, were stopped up to obtain greater results.

Test 3D.—With one discharge from a valve-closet (filled to brim) into branch H, the "Narrow-band" D-trap, fixed at J, lost $\frac{1}{4}$ in.; the "Helmet," at K, $\frac{1}{2}$ in.; the "small" "Anti-D-trap" at F, $\frac{3}{8}$ in.

Test 4D.—With the "Helmet" fixed at J, and the "Narrow-band" D-trap at K, a similar test as last syphoned $\frac{1}{4}$ in. depth of water out of the "Anti-

* During this test the "Helmet" trap was fixed on the branch, K, and lost exactly *half* its seal—*i.e.*, $\frac{5}{8}$ in. depth of water was syphoned out of this trap by the discharge of the five pailfuls of water down the upper closets.

D-trap," fixed at H, the trap through which the discharge had passed; $\frac{1}{4}$ in. out of the "Helmet;" $\frac{1}{2}$ in. out of the "Narrow-band" D-trap; and $\frac{5}{8}$ in. out of the "small" "Anti-D-trap," F.

Test 5D.—With a *full-sized* D-trap* fixed at K, instead of the "Narrow-band" D-trap, and branch, J, stopped up, a discharge of water from the valve-closet, as before, through branch H *syphoned half-an-inch* depth of water out of the *full-sized* D-trap, and nearly half-unsyphoned the small "Anti-D-trap," F. In this test, as in the others in this series, the main soil-pipe was opened to the atmosphere (full bore) at top and bottom.

Test 6D.—With Beard and Dent's 4-in. "P" trap (Fig. 58) fixed at K, and a full discharge, as last, from the valve-closet fixed over its trap at H, the 4-in. P-trap lost more than half its dip; but with a 2-in. air-pipe on its outgo its "standing water" could not be interfered with by the fullest discharge from the valve-closet fixed at H, nor with a closet fixed on any other branch of the piping.

Test 7D.—This test was made with a "round-pipe" trap (Fig. 59) and the result was very similar to the last—Test 6D—*i.e.*, it lost $\frac{3}{4}$ in. without ventilation, but with ventilation it lost nothing.

Test 8D.—With the "small" "Anti-D-trap," F, under the lower closet, ventilated, and a "Narrow-band" D-trap fixed at K, not ventilated, a discharge from a valve-closet filled to brim, through branch H,

* It has been proved over and over again, as the reader will have noticed, that the D-trap is subject to syphonage.

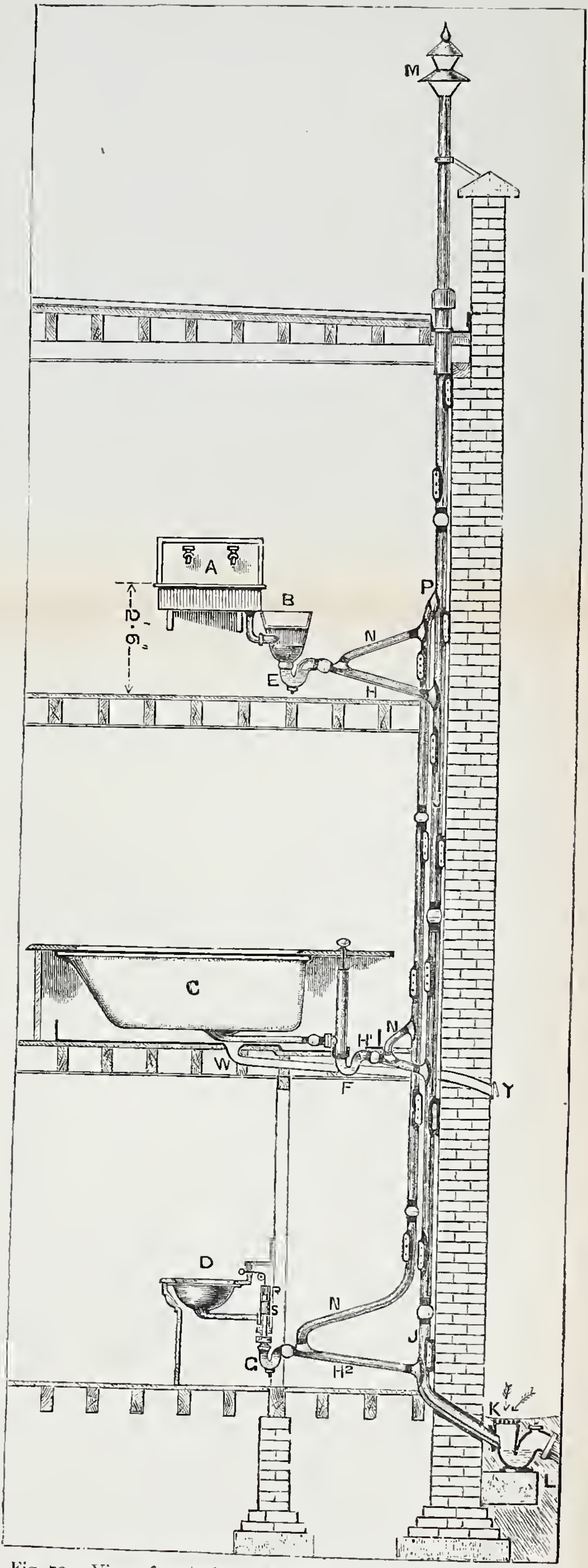


Fig. 70.—View of a stack of Waste-pipe, with a Washing-up Sink and Slop-sink combined, Bath, and Lavatory fixed upon it, showing perfect ventilation of same.

To face page 175.

as before, the "standing-water" in the "Anti-D-trap" is not affected in the slightest degree, but the D-trap suffers and loses *one-third* of its seal, nothwithstanding that the air-escape pipe from the "Anti-D-trap" is within 7 or 8 ft. of it.

Subject exhausted.

I will not occupy the reader's time with further results of my experiments with traps, either for fixing on waste-pipes or soil-pipes, for if I have not exhausted the subject I have every line of space that can be given to it here; and though I have shown how to syphon the water out of traps, I am not desirous of showing how the patience of the reader can be "syphoned" out. I will, therefore, simply add, the experiments proved that where *tiers* of traps of any description are fixed upon one main pipe, for receiving discharges from water-closets, stop-sinks, baths, quick-waste lavatories, &c., each individual trap or branch must be ventilated, if the traps upon the piping are to maintain their "seals" intact.

Displacement of Water in Traps.

There are three distinct actions upon traps fixed on one stack of piping, each one of which may cause loss of water in unventilated traps. (1) The water may be *forced* out of them by *air pressure—i.e.*, a full discharge into the main pipe from an upper trap forms itself into a sort of water-plug and drives the air in the pipe down before it and out through the lower traps, unless a way of escape is made for it. See Test 1, p. 162, also Fig. 66, Plate IV., show-

ing the water forced out of trap, fixed at D, as if it came from a fountain. (2) The water may be forced through a trap by falling into it from some height, as from the basin of a valve-closet, especially when the distance between the basin-valve and the "standing-water" of the trap is greater than a 9-in. or 10-in. joist requires. We have already considered this action on pp. 162, 163. (3) The water may be *syphoned* out of traps. A few words on the cause of syphonage—*i.e.*, the displacement of water in traps by discharges sent through a pipe on which traps are fixed—may be interesting. We have no time to go into the matter thoroughly, so will keep outside the laboratory, and simply look at the matter from a common-sense point of view, leaving a fuller investigation for a more leisurable time—should that ever come.

Trap-Syphonage Explained.

Trap-syphonage is chiefly caused by the atmospheric pressure being greater on one side of a trap than on the other. When a body of water is sent through a soil or waste pipe it interferes with the pressure of air on the "standing-water" in the *outlet* of the trap or traps fixed on such pipes. The pressure of air being thus removed, or partially removed, from the outlets of the traps, by the passage of the discharge—like a *water-plug*—in the main pipe, the "standing-water" of the traps is forced down on the inlet sides of the traps (by the greater pressure of the air on this side), and rising up on the outlet sides, it instantly wastes away through the branch-wastes, unsealing the traps and allowing

the air to pass through them and out with the discharge through the main waste—*i.e.*, a body of water discharged from the bath, E (Fig. 54), would, on passing through the main waste, J, interfere with the air pressure on the "standing-water" on the outlet side of the lavatory trap, H. The pressure of air being then greater on the *inlet* side, the water would be forced down on this side, and, rising up on the *outlet* side, it would readily escape through the branch-waste, M, unsealing the trap, and allowing the air to pass through the lavatory basin, F, and out with the discharges through the waste-pipe, J. I explained in the earlier part of this lecture that directly a trap became unsealed, the air rushed through it all the time the discharge was passing through the main pipe on which the trap was fixed. It passes through a 1½-inch syphon trap, fixed, *e.g.*, on a 30 feet length of 1½-inch piping, and when the pipe is fully charged, as from a bath, at the rate of *about* 50 feet (lineal) per minute.

Therefore, to prevent the "standing-water" from being displaced in a trap, the weight of the air should be equipoised on both sides of the seal, and this is readily done by fixing a ventilating-pipe on the outlet of the trap—for the air can always reach the inlet in properly arranged sanitary fittings.

An experiment was given with the model bath and lavatory arrangement—illustrated in Fig. 51—to prove this. A good flush of water was sent out of the bath, A, which at once removed or inter-

fered with the pressure of air on the "standing-water" on the outer side of the lavatory trap, D; but, to prevent the syphonage of this trap, the pressure of the air was removed, or interfered with, on the inlet side by sealing over the dip (*i.e.*, inserting the plug); and notwithstanding the rapid discharge of about three gallons of water from the bath, through the waste-pipe, H, the lavatory trap D was left intact. The plug was then removed, and another flush of water was sent out of the bath, but this instantly unsyphoned the lavatory trap. Another experiment was then made with the trap open to the atmosphere on each side of its water seal—*i.e.*, the stop-cock, E, was opened, and the trap ventilated, and the plug being out of the basin, the weight of the air was equalised on the inlet and outlet sides of the "standing-water" of the trap, and though two or three good flushes of water were sent through the main pipe from the bath, the water in the lavatory trap was not affected by it in the slightest degree.

Those who understand the principle on which pumps raise water ought to understand this principle well enough. You know that the atmosphere exerts a pressure of nearly 15 lbs. on every exposed square inch, and that, therefore, it will lift a column of water 33 feet high. You know that a suction-pipe of a pump, when it does not exceed this height—though practically the pump will not work at all at this height, and works better when

the suction is under 26 feet in height—is full of water, and that this water is kept there by the weight of the air on the surface-water in the well. I have here a glass trap (see illustration, Fig. 68). I remove the atmospheric pressure from its mouth or inlet, by shutting the stop-cock, B, and the water is kept up in the dip-pipe, A, as you see it, by the air pressure on its outlet, C; but if I allow the air to pass into the inlet by opening the stop-cock, the water finds its level instantly by running out of its outlet, C. Prick the suction-pipe of a pump, and allow the air to pass into it, and the water is out of it—well, quicker than our soldiers were out of Candahar.

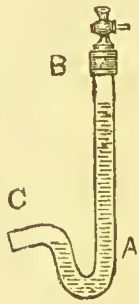


Fig. 68.

But in trap-syphonage there is not only the weight of the air, or atmospheric pressure, to consider; there is also the pulling power of the discharges through the piping, and this often very considerable. A large flush of water is sent into a waste-pipe, or a soil-pipe, which is from 50 to 70 feet high, we will say, and this flush passes through the piping as a sort of "water-plug" several feet in length, exerting a pulling action all the way through, and producing a partial vacuum in every branch upon it, unless such branches are ventilated. When these branches are not ventilated, the vacuum produced in them is instantly filled by the atmospheric pressure upon the trap inlets, forcing the water out of

them, and rushing through to supply the vacuum; but I believe "scientists" now say there is no such thing as a perfect vacuum.

Trap Ventilation: Bad Arrangement.

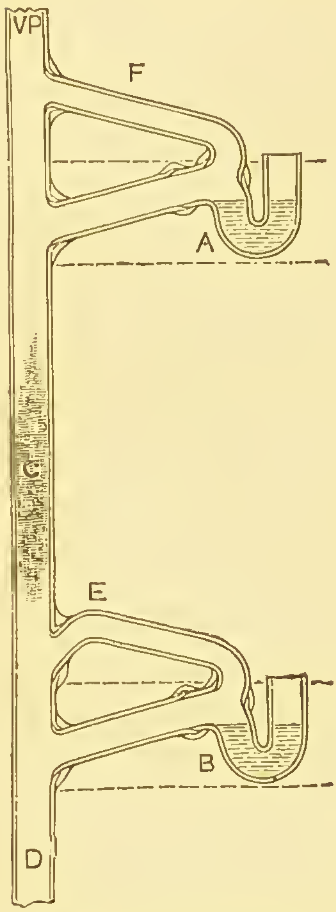


Fig. 69.—Trap-ventilation: Bad Arrangement.

Enough has been said on the *necessity* of ventilating traps, both for preserving them from syphonage, and the injurious effects of stagnant air. A word, with the aid of illustrative examples, will suffice on the *mode* of ventilating them. To take an air-pipe from a trap when fixed on a stack with more than one trap upon it, and carry it into the main waste or soil-pipe, as many do, is not ventilating the trap according to its needs: for during the time the discharge is passing through the main pipe—*i.e.*, when the ventilation is most needed—all ventilation is shut off from the lower traps; *e.g.*, a discharge sent through an upper trap, A (Fig. 69), would pass through the main pipe in a sort of water-plug, as shown at C, and shut off the air-pipe, E, to the lower trap, B.

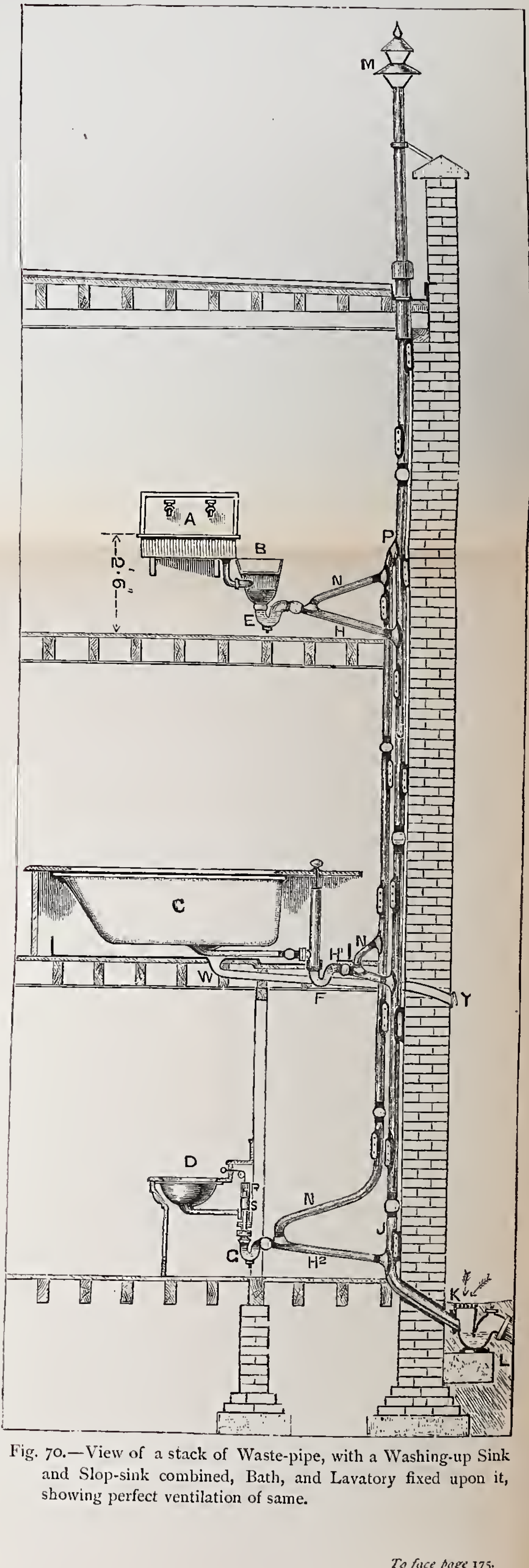


Fig. 70.—View of a stack of Waste-pipe, with a Washing-up Sink and Slop-sink combined, Bath, and Lavatory fixed upon it, showing perfect ventilation of same.

To face page 175.

Traps properly Ventilated.

In Fig. 70, Plate VI., I show what I consider the best method of ventilating waste-pipes* and traps. The discharging end of the main waste-pipe, J, is open to the atmosphere at K, and the top end is open to the atmosphere, above the roof, having an extracting cowl upon it, as shown at M. A "washing-up" sink, A, with a "water-shoot" slop-sink, B, combined, are branched into the main waste on the second floor. On the floor below, a bath, C, is fixed, and its branch waste, H^1, is taken into the same main waste; as is also the branch, H^2, from the lavatory, D, fixed on the ground floor. Each branch is ventilated, as shown at N, N, N, and the air-pipe from these branches is taken into the air-pipe of the main waste, as shown at R, above the highest branch; so that each trap is perfectly ventilated, and in such a way that no discharge passing through the main waste—from the sinks, lavatory, or bath—can disturb the water in any of the traps, E, F, G; *i.e.*, a discharge from any of the "fittings" can neither unseal the trap through which the discharge has passed, nor any other trap fixed on the main piping. Also, by this arrangement, a current of air is made to pass through every inch of the main waste, and no air is allowed to remain stagnant (to damage the traps and piping) in any part of its branches. The main waste,

* See Fig. 93, Plate VII., showing ventilation of soil-pipes and closet-traps.

branches and traps are all of small size, for better cleansing purposes.

In high buildings, it wants a long ladder to reach from the bottom to the top, and a clear head to ascend it, but divided into stages the ascent may be made easy enough for a land-lubber to climb to the top. We have come to our present point in this trap question by stages. (1) We saw that traps under sanitary fittings were needed; (2) that the traps largely used for such purposes were *un*sanitary—*i.e.*, *non*-cleansing; (3) that traps could be made sanitary—self-cleansing; (4) that self-cleansing *round-pipe* traps, when fixed in certain positions, were easily un-syphoned, and, like the cow which kicked over the pail of milk which she had given, did more mischief than good; (5) we found out how to remedy the evil of trap-syphonage. And now all that I have to do, in concluding this subject, is to ask you to make self-cleansing traps instead of non-cleansing ones. Master plumbers may say, "But our apprentices and journeymen make up D-traps in idle times, and if we buy 'Syphon' traps we shall have nothing for them to do when work is slack!" There is a* story told of Bishop Wilson, that on ordering a coat, he expressly charged the tailor not to make it in the fashion of the gallants of the day, and only to put in two rows of buttons; buttons all over being then the fashion. "My lord," said the tailor,

* Note to "Passages from the Life of the Rev. Robert Anderson."

"what then becomes of all the button-makers?" The bishop answered, "Sayest thou so, good Master Robert? Then button me all over." Now, though I want you to cease making D-traps, I do not want to prevent you from *making* traps. If you cannot bend lead pipes, and form them into traps, "S" or "half-S" shape, by hand, as the traps here by my side, you can knock them up out of sheet lead, in two halves, and solder them together, as I daresay many plumbers here have often done. If any one objects to the soldered seams of such traps, you have a good reply—namely, that there is less solder in a syphon-trap with soldered seams than there is in a hand-made D-trap. I have had some syphon—*i.e., round-pipe*—traps made by hand, bent out of patent lead pipe, for you to examine after the lecture is over. They are "S" and "half-S" traps in various sizes—1-inch, 1½-inch, 2-inch, and 3½-inch—as true and as good as machine-made traps, and there is not a particle of solder about them.

As I am laying down the principle on which self-cleansing traps are made, rather than pointing out the various traps made, I will pass on to self-cleansing traps for fixing *outside—i.e.*, in connection with drains. I should say, however, that there are some traps here, of various makes, which I shall be glad for any one to examine after the lecture is over.

Any earthenware trap which can have its previous contents washed out by a flush of water

sent through a waste-pipe, soil-pipe, or drain, may be set down as self-cleansing, no matter who makes it or where it comes from.

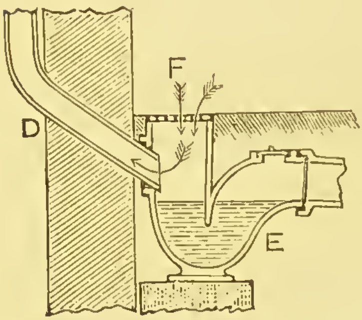


Fig. 71.—Section of "Drain-interceptor."

Fig. 71 shows a stone-ware "drain-intercepting" trap, which I constructed some years ago, for receiving the discharging ends of waste-pipes and exposing them to the atmosphere, thus cutting off the connection with the drain perfectly.

Fig. 72 shows my *large* size stone-ware drain intercepting trap, for disconnecting rain-water drains, &c., from the soil-drain. To avoid long

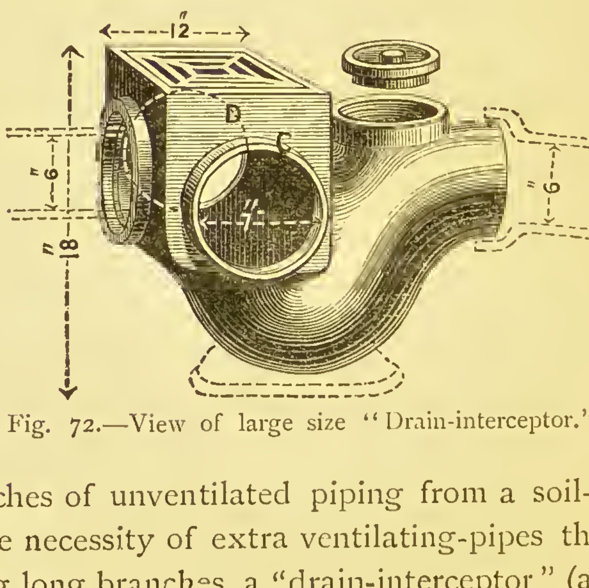


Fig. 72.—View of large size "Drain-interceptor."

branches of unventilated piping from a soil-drain, or the necessity of extra ventilating-pipes through fixing long branches, a "drain-interceptor" (as Fig.

71 or 72—or the size between these two) should be fixed close to the main drain, and the clean water drain brought into one of its three sides—B, C, D—as shown in the woodcut. At the *foot* of the rain-water pipe could be fixed a stoneware "Rain-water Shoe," as shown in Fig. 73, which I designed and patented, for disconnecting drains from rain-water pipes and giving access both to the drain and pipe. Or when the soil drain is close to the rain-water pipe, a drain-

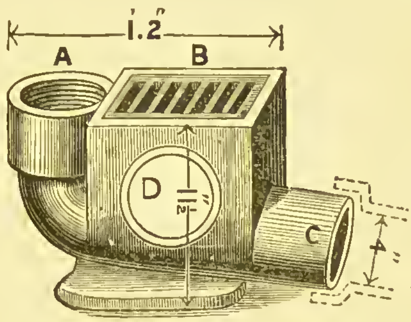


Fig. 73.—View of "Rain-water Shoe."

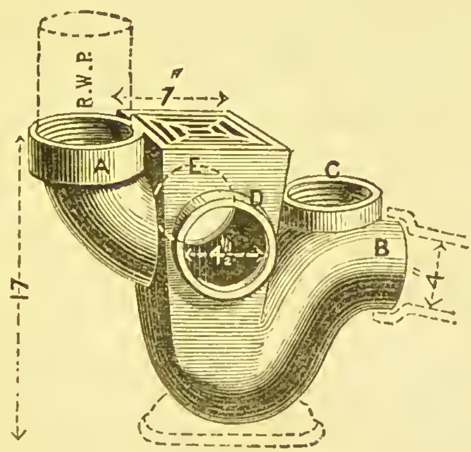


Fig. 74.—View of "Rain-wa'er Trap."

intercepting trap, as shown in Fig. 74, of my design—for disconnecting rain-water pipes from drains—could be fixed, and this trap could also

be made to take the waste-pipe from any draw-off sinks or lavatories near it.

Fig. 75 shows my patent trap for disconnecting soil pipes from drains. It is specially constructed for treating the ends of soil-pipes as just explained to waste-pipes. The trap is self-cleansing. The

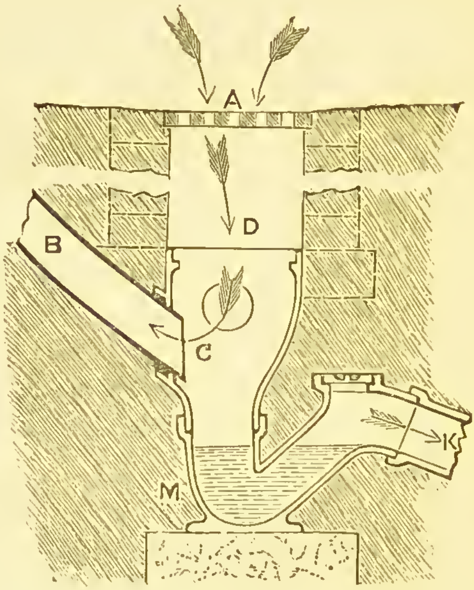


Fig. 75.—"Soil-pipe Disconnector."

value of such disconections will be explained in a subsequent lecture.*

Fig. 76 shows Buchan's stone-ware trap for disconnecting pipes from drains, and drains from sewers. This trap is self-cleansing, as may readily be seen by a glance at the diagram. The cleansing power of this trap is helped by its water-drops; and by having a vertical opening to the

* See pp. 226 to 229.

atmosphere right over its inlet, any sewer air passing through the "standing-water" of the trap

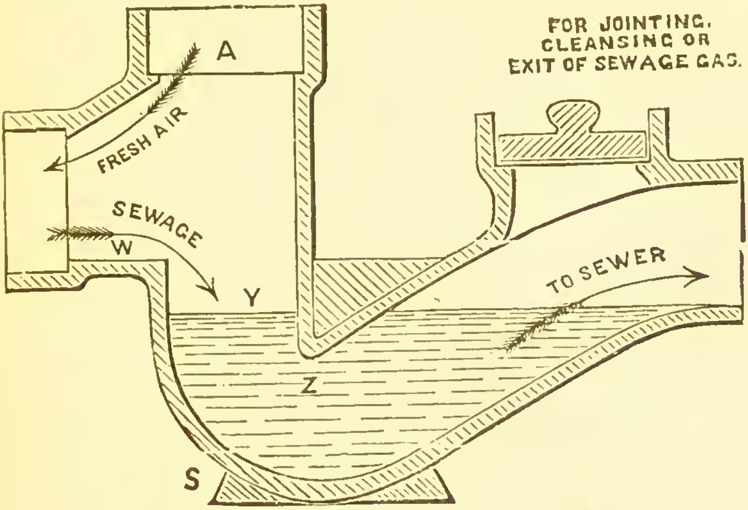


Fig. 76.—Buchan's Disconnecting Trap.

would readily get away, or be largely diluted with fresh air before passing into the drain.

Fig. 77 shows a section of my patent "ventilating drain-syphon and sewer-interceptor"—the

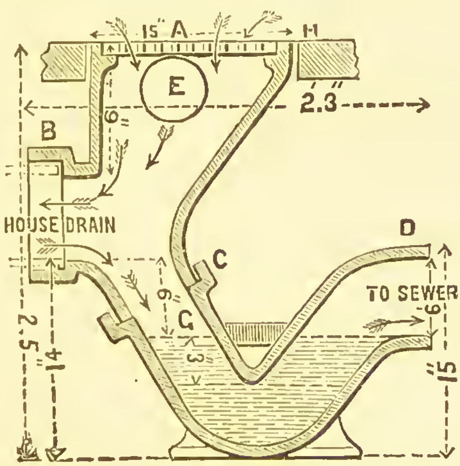


Fig. 77.—Section of a 6-inch "Sewer-interceptor."

principle being just the same as the last trap. This trap has a greater water-drop for driving out the contents of the water left "standing" in the trap, and the body of the trap is made smaller than its inlet and outlet, so as to hold less * water—for easier changing, &c.

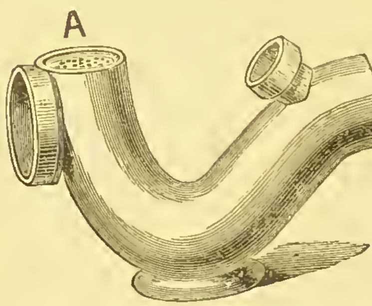


Fig. 78.—Weaver's Trap.

Fig. 78 shows a section of Weaver's drain ventilating trap. This trap is a great improvement upon the man-hole drain-syphon; but the want of a vertical fall or drop on the "standing-water" prevents it from being so self-cleansing as it might be, and it also holds too much water for the contents to be easily changed.

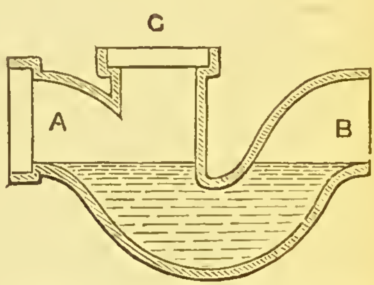


Fig. 79.—"Croydon" Syphon.

Fig. 79 shows a section of the "Croydon" syphon. This trap has been largely used during the last few years. It is infinitely superior to the old syphon generally used for trapping off drains from sewers, but it is not

* This 6-inch "Sewer-interceptor," with greater water seal than either the "Croydon" or Drain-syphon (Fig. 48), holds fully one gallon less of water; for the 6-inch "Sewer-interceptor" (Fig. 77) holds just one gallon, a 6-inch "Croydon" over two gallons, and a 6-inch common Drain-syphon two gallons and a quarter.

absolutely self-cleansing when used for such purposes, for the body of the trap is too large for the water previously standing in the trap to be washed out by a flush of water sent into it.

Enough has been said on traps for intercepting pipes from drains, and drains from sewers; those of you who care to push inquiries further will doubtless have an opportunity of seeing, and examining, many such traps at the Medical and Sanitary Exhibition, which will be opened at South Kensington in a week or two. I hope to show some of these traps fixed for disconnecting drains from sewers, &c., on large diagrams in a subsequent lecture, but it is now time that we "disconnected" our thoughts from such matters, or I shall "drain" your patience and "intercept" your good wishes.

LECTURE V.

HOUSE DRAINAGE AND VENTILATION.

Privies. Close-stools. Closets in Pompeii, Paris, Berlin, Spain, Edinburgh, London. Water-closets—Cummings', Prosser's, Bramah's, Pan-closet, Valve-closet, &c. Soil-pipes—Material, Size, Positions, Disconnections from Drains, and their Ventilation. Tacks soldered to Pipes. Waste-pipes generally; with Sizes, Positions, Disconnection from Drains, and Ventilation.

OUR subject to-night is "House Drainage and Ventilation." For convenience, and easier reference to the diagrams, I shall treat this subject somewhat differently from the course laid down in the syllabus. Instead of considering soil-pipes and waste-pipes in one lecture, and their disconnection from drains with their ventilation in another, I propose clearing them off completely as I go on.

Our last subject extended itself so much that if I kept strictly to the syllabus to-night, I should have to drop out the first half of our present subject, *i.e.*, one night's lecture. When the Irishman in his travels lost a night's sleep, he regained it the following night by sleeping on two beds, placed on top of one another. I cannot get over my difficulty so easily, for I cannot get two lectures into one: besides, it would hardly be sanitary, for, to say nothing about the ventilation

of this room where we shall have to be for three or four hours, the sewer ought not to be so connected with soil-pipes and waste-pipes—a space ought always to be between them. So I ask your permission to postpone the second half of this subject—"House Drainage and Ventilation"—to the evening announced for the lecture on "The Art of Lead Laying," which I shall be glad to drop out of the course.

Plumbers begin with Soil-pipes.

In commencing the internal plumbing* of a house, plumbers generally begin with soil-pipes; but before they can get such pipes ready for fixing, they require to know the kind of water-closets to be fixed upon them, so as to arrange the branches and traps accordingly. I will to-night follow their practice, and begin the subject of House Drainage with *Soil-pipes* and Water-closets.

A rapid glance at some of the first water-closets used inside a house may not be uninteresting.

Privies.

Privies served their purpose well enough when every man had a garden or piece of ground, but when men congregated together in cities and towns, remote places for putting such conveniences could not be found, and drains and sewers had to be made, into which the general slops of the house were thrown.

Close-stools.

Instead of building water-closets as we do

* In a book called "The London Art of Building," published in 1734, plumbers' work is called "Plumbery."

now, the rich ancients used close-stools, or pans which were frequently made of gold, besides the water-closets which were made in vaulted recesses in their kitchens.* The Romans placed vases, called *gastra*, upon the edges of roads and streets, just as we now fix urinals.

Water-closets in Pompeii.

In Sir William Hamilton's account of "Discoveries at Pompeii," he says, in a paper † read before the Society of Antiquaries, in 1775, "Close to the Temple of Isis is a theatre, no more of which has been cleared than the scene, and the corridor that leads to the seats. In this corridor was a retiring-place for necessary occasions, where the pipe to convey the water, and the basin, like that of our water-closets (A.D. 1775) still remain, the wood of the seat only having mouldered away by time." As Pompeii was destroyed—by an eruption of Mount Vesuvius in the year A.D. 79—this W.C., which Sir William Hamilton saw, must have been 1,700 years old at the least. Fosbroke, in his "Encyclopædia of Antiquities" (p. 397), says, "The water-closet in the Palace of the Cæsars is adorned with marble arabesques and mosaics; at the back of one is a cistern, the water of which is distributed by cocks to different

* In writing of the discoveries made by antiquarians in Pompeii, Fosbroke says, in his "Encyclopædia of Antiquities" (p. 78), "The kitchen is descended by stairs, on the left hand of which is an arched stone dresser, used as the hearth for cooking. On the right hand is a vaulted recess for a privy, three feet deep, formerly provided with a door and seat, an ancient appendage to a kitchen, still retained in modern Italy."

† "Archæologia," vol. iv., p. 168.

seats." Olympiodorus says that in the Thermæ of Antoninus (which were baths and gymnasium combined) there were 1,600 seats of marble pierced like *chaisés-percées* for the convenience of those who bathed.* The fall of the Roman Émpire led to the disuse of *water*-closets, and to a return to the customs of earlier ages.

Disposal of Slops in Paris

Beckman says that in Paris, so late as the fourteenth century, the people had the liberty of throwing anything from their windows whenever they chose, provided they gave notice three times before by crying out, "*Gare l'eau!*" This practice was, we learn, forbidden in 1395.† A like practice seems to have continued much later in Edinburgh; for in A.D. 1750, when people went out into the streets at night, it was necessary, in order to avoid disagreeable accidents from the windows, that they should take with them a guide, who, as he went along, called out with a loud voice, "Haud your han!" This must have been a good time for hatters and tailors. At that period, when the luxury of water-closets was unknown, it was the custom for men to perambulate the streets of Edinburgh, carrying conveniences (pails) suspended from a yoke on their shoulders, and enveloped by cloaks sufficiently large to cover both their apparatus and customers, crying, "Wha wants me for a bawbee?" ‡ It has since been used

and Edinburgh.

* Fosbroke's "Encyclopædia of Antiquities," p. 67.
† Beckman's "Inventions," vol. i., pp. 277-281 (1846).
‡ "Letters from Scotland" (1760).

against the Edinburgh people as a joke or satire upon an ancient custom. By way of set-off, however, it may be observed, that in 1846 almost every house in Edinburgh had a water-closet.

Paris Laws.

In a Parisian code of laws, which was improved in 1513, it was expressly ordered that every house should have a *privy;* but in the year 1700 they had not this "luxury" in every house, for at that time, only 180 years ago, the police had instructions to see that each house had a privy, or to lock the house up if the occupants did not make one within a month.

Spain.

If we turn to Spain, matters were worse, for we are told that "the residence of the King of Spain was destitute of this improvement, at the very time that the English circumnavigators found privies constructed, in the European manner, near the habitations of the cannibals of New Zealand." *

Privies in Germany.

Privies seem to have been common in the large and flourishing towns of Germany much earlier than in Paris. In the annals of Frankfort-on-the-Maine, we are told that an order was issued, in 1496, by the Council, forbidding the proprietors of houses, situated in a certain place planted with trees, to erect privies towards the side where the trees were growing In 1498, George Pfeffer von Hell, I.U.D., Chancellor of the Electorate at Mentz, fell by accident into a privy, and there

* Foot-note, "Cook's first Voyage," vol. ii., p. 281.

perished—a privy chancellor! A writer,* speaking of Berlin in 1846, does not say much in favour of the sanitary arrangements there at that time—thirty-five years ago. He says, "In most of the houses small closets are located on the landings of the stairs, which require to be emptied every other night to the no great satisfaction of the olfactory nerves. Nor are the streets kept in a very proper state, large puddles of filth being allowed to collect before the doors even of the best houses, and which, especially in the hot summer months, diffuse a most horrible stench."

English Water-closets

But let us return to our own country. Stow tells that, "In 1290, the monks of White Friars complained to the King and Parliament, that the *putrid exhalations* arising from the Fleet river were so powerful as to overcome all the frankincense burnt at their altars during divine service, and even occasioned the deaths of many brethren. Many attempts were made to cleanse this river and restore it to its ancient condition of utility as a navigable stream; but they proved unavailing, and the stream which formerly conducted vessels with merchandise as far as Fleet Bridge and Old Bourne (now Holborn) Bridge, if not farther, became, in the language of Pope,

> 'The king of dykes! than whom no sluice of mud
> With deeper sable blots the silver flood.'"

Sir John Harrington is credited by Nares with

* Beckman's "Inventions," vol. i., pp. 277-281. Foot-note (1846.

the invention of the English water-closet, or *latrine*, in Queen Elizabeth's time; but Fosbroke says that this is a mistake, though probably Sir John made them known in England. Portable close-stools * were used in the reign of Queen Elizabeth, and placed in garrets, and were called "ajaxes." †

Aubrey, writing in 1718, describes a water-closet he had seen. He says, "Here [at Sir Francis Carew's, Beddington, Surrey] I saw a pretty machine to cleanse an 'House of Office,' viz., by a small stream of water no bigger than one's finger, which ran into an engine made like a bit of a fire-shovel, which hung upon its centre of gravity, so that when it was full a considerable quantity of water fell down with some force and washed away the filth." ‡

An old Book on Plumbing.

I have been looking through a very interesting old book, entitled "The London Art of Building," published in 1734—147 years ago—and though "the Plumber" occupies a place of honour in the book, and a schedule of plumber's work is given, there is nothing in the whole book to warrant one in supposing that *traps* were used in those days.§

* The regal one was made of silver.

† "American Mechanical Dictionary," vol. iii., p. 2763.

‡ Aubrey's "Surrey," vol. ii., p. 160.

§ Campbell in his book, "A Compendious View of all Trades practised in the Cities of London and Westminster," published thirteen years after this (in 1747), in speaking of the plumber's duties, does not say a word about *traps, soil-pipes*, or water-closets, except that the plumber must lay on water to the "Office Houses." Under the head of "Plumbers' Business," he says—"He must

Nor is there the smallest reference to water-closets in the "plumber" or "joiner"—for making the seats, or "mason"—for shaping the closet pan just referred to; but many references are made to the drainage of a house. I have culled a few extracts, and will leave you to determine whether there is enough in them to warrant one in saying that soil-pipes or water-closet wastes were fixed in those days—I mean soil-pipes from water-closets fixed "upstairs." There can be no doubt about water-closets being at that time fixed in yards, and places where they could be connected with the drain direct. Here is one of the Rules:—

"That convenient Drains, to carry away Soil, &c., be well contrived, and secretly placed, with Vents to discharge the noisome Vapours that usually arise from them." *

"*Conduits.* Sewers or Gutters to convey away the Suillage of a House."

"*Sewers*, in Architecture, are Conduits, or Conveyances, for the Soilage and Filth of a House." †

"That convenient Cisterns be well placed, plentifully to furnish every Office with Water; and that proper Machines be made to raise the same therein."

Under the heading, "of Plumber's Work," I have extracted two or three items, together with some of the scheduled prices, which will make some sigh for those good old times:—

"Flats, Roofs, Guttering, 7 to 10 lb. lead to the foot superficial."

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furnish us with a cistern for water, he must fix a sink with lead, he covers a house with lead when it requires it, and makes gutters to carry off the rain-water, he makes pipes to convey water into our kitchens and Office Houses."

* "The London Art of Building" (1734).

† "*Ibid.*

"Lead Rain-water Pipes, Rain-water Cisterns, Battened Cisterns."

"Lead pumps," Water pipes from ¾ to 7-ins. Bore."

"Brass cocks and bosses up to 3-ins.," "Stop-cocks" and Ball-cocks," &c. &c.

As to some of the prices—established prices—charged by the London plumber of that day:—

"Sheet-lead, either cast or milled, 18s. per cwt."

"Lead Rain-water pipes, R-W-cisterns, batten'd cisterns, Lead pumps,—including soder * and labour, † at 22s. per cwt."

"All Water Pipes from ¾ to 7 inches Bore (labour and soder), 20s. per cwt."

"Brass cocks 1¼ to 3-ins. at 1s. 3d. per lb."

And though the price of "soder" is set down at 8d. the pound, the prices of the joints were charged as follows, viz.:—

"Soldering	a joint	on a	water-pipe	¾-in.	Bore,	2s. 6d."
"	,,	,,	,,	1-in.	,,	3s."
"	,,	,,	,,	1½-ins.	,,	3s. 6d."
"	,,	,,	,,	2-ins.	,,	4s. 6d."
"	,,	,,	,,	3-ins.	,,	7s."
"	,,	,,	,,	4-ins.	,,	10s."
"	,,	,,	,,	5-ins.	,,	12s. 6d."
"	,,	,,	,,	6-ins.	,,	16s."
"	,,	,,	,,	7-ins.	,,	21s."

At the end of the schedule of prices "of Plumber's Work," occur special notices which are amusing:—

"N.B.—That there are some Men of this, as well as of all other Professions, that will sell for less Profit than others the following advertisement is a Proof."

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* Spelled "soder."

† Though the rate of plumber's wages is not given in this book, R. Campbell, Esq., writing a few years after this time, in 1747, says—"A journeyman (plumber) earns from 15s. to a guinea per week, working from 6 to 6." The rate of plumber's wages, in London, now (1881) is 10d. per hour.

"Whereas it has been the practice of many Plumbers to charge an extravagant Price for Leaden Pipes (to the great Discouragement of Gentlemen), they not being satisfied under Thirty per Cent. Profit, to prevent which Imposition for the Future, John Heysham, Plumber in Eton, near Windsor, makes and sells Leaden Pipes of all sizes."

and then the prices for such pipes follow. But this is going away from my subject.

Marble Water-closets.

As far as I can make out, Fig. 80 represents the best form of water-closet used in England about a century or a century and a half ago. These water-closets were made of marble—A the pan; B the waste-plug; C the service-pipe; D the overflow. We have one (an old one) in our warehouse to-day. In examining the sanitary arrangements of Osterley House, a year or two ago, I found two such water-closets. A niche in a fair-sized room was formed to receive the marble closet pan, and a door, shutting up close to the seat, hid the whole arrangement from sight. A lead soil-pipe was connected with the outlet plug-waste of the pan, and continued from it to the drain, which was brought into the house to receive it. The soil-pipes had no ventilation.

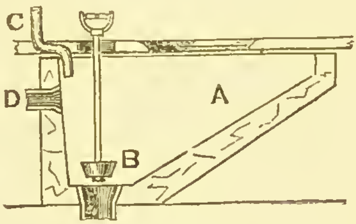


Fig. 80.

Patents of privilege, or monopoly, have been granted for several hundred years. The annals of some in very many instances have gone into

oblivion. No. 1, standing first in supplementary numerical order, was a patent of privilege, or monopoly for 31 years, granted to Simon Sturtevant, on the 29th of Feb., A.D. 1611, "for 'Metallica,' a treatise to *neale, melt,* and work all kinds of metal *ores, irons,* and *steeles,* with sea coale, pit coale, earth coale, and brush fewell."

The first patent in this country under Laws of Patents for Inventions, as far as I can glean, was granted by James I. in 1617; but according to the Records of the Patent Office, not a single patent was taken out for a water-closet until the year 1775, or 158 years after special licenses were granted for protecting inventions. The presumption is, therefore, that no water-closet other than that of a simple nature (as Fig. 80) had been in use up to this date, 1775. But the specification of the first patented water-closet clearly establishes the fact that water-closets were in use at that time, for the inventor calls his invention a "Water-closet upon a New Construction;" and the drawing annexed to the specification clearly proves that soil-pipes at that time were well known, and that water-closets were fixed "upstairs," *i.e.*, in various parts of the house.

Cumming's Water-closet.

In the year 1775 Alexander Cumming, a watchmaker in Bond Street, took out the first patent for a water-closet—and many closets in use to-day are more unsanitary than this one. Fig. 81 is a faithful representation of the drawing annexed

to the inventor's specification. The water is brought into the basin, very low down, at E, and is kept in the basin by what the patentee calls the "slider" *e*. The details are all carefully engraved and explain themselves. I will give two or three extracts from Cumming's specification, as it will

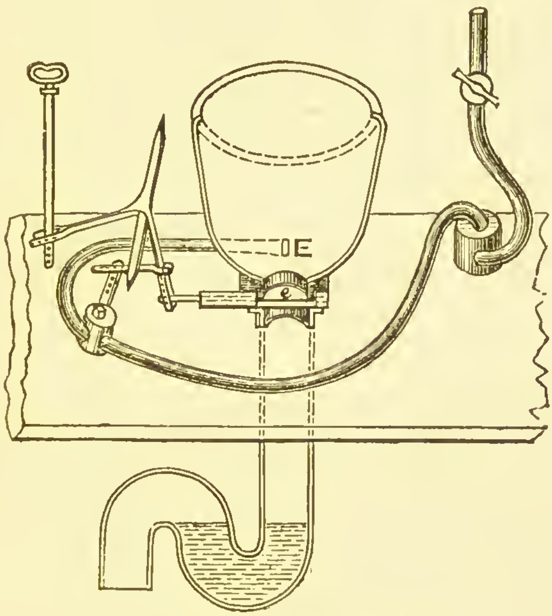


Fig. 81.—Cumming's Closet.

show us that traps were used under closets at this period, and that they were offensive; also that soil-pipes were fixed without ventilation, and that such pipes emptied themselves into drains, and the drains into cesspools :—

"The advantages of the said water-closet depend upon the shape of the pan or bason, the manner of admitting water into it, and on having the stink trap so constructed that its contents shall, or may, be totally emptied every time the closet is used. . . . ."

"The stink-trap hitherto used for water-closets is too well known to require a description here; and although it may serve effectually to cut off all communication of smell from the drains, pipe, and cesspool, it becomes in itself a magazine of fœtid matter, which emits an offensive smell every time that it is disturbed by using the water-closet.* In this water-closet, the pipe which carries off the soil and water is recurved about twelve or eighteen inches below the pan or bason, so as constantly to retain a quantity of water sufficient to cut off all communication of smell from below, and this stagnated water in the recurved part of the pipe is totally emptied, and succeeded by fresh every time the pan or bason is emptied."

As shown in the illustration, the trap under Cumming's closet is a *round-pipe*, or syphon-trap.† And as he includes it in his patent I take it that this was the first time it was used in England (1775). But it does not follow that syphon-traps had not been used before; for the ancients knew the working of *syphons*, and may have used syphon-traps.

"Syphons" are shown in Egyptian tombs of the date of 1450 B.C. The syphon was a favourite contrivance with Hero of Alexandria (150 B.C.) in his various toys and automata, of which the Cup of Tantalus is a favourite instance.‡

* If the trap referred to here, by Cummings, as the "stink-trap *hitherto* used," is the D-trap, its character was as bad then (1775) as it is to-day, for he goes on to say that "it becomes in itself a *magazine of fœtid matter, which emits an offensive smell every time that it is disturbed by using the water-closet.*"

† With regard to syphon-traps stopping up, my foreman fixed some 4-in. (or 4½-in.) cast-lead syphon-traps thirty years ago, and he went and examined them the other day, and they are still in perfect working order. These traps were made from *sand-cores*, and moulds, made by Chalklen, brass founder, the inventor of the *iron-frame* for Bramah's closet. Bonham, his nephew, succeeded to his business.

‡ Knight's "American Mechanical Dictionary," vol. iii., p. 2189.

About two years later (*i.e.*, in 1777) Samuel Prosser, a plumber living in the parish of Saint Martin-in-the-Fields, took out a patent for what he describes in his specification as "A Water-closet upon an entirely New Construction, which will always remain free from any Offensive Smell." A very desirable closet for everybody to have to-day if such were the case. But I should say it was about as bad as the pan-closet, *i.e.*, a water-closet which would *never* "be free" from an "offensive smell." Fig. 82 shows this closet, as copied from the drawing annexed to the inventor's specification. Two pages suffice to include his specification, preamble, claims, and license. It will be seen by the woodcut that excremental matter has free access to places where it could never get properly cleansed.

Prosser's Water-closet.

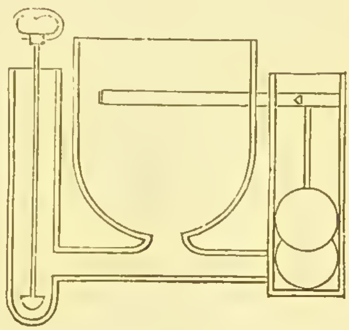


Fig. 82.
Prosser's Water-closet.

In 1778, Joseph Bramah, of Cross Court, Carnaby Market, Middlesex, cabinet-maker, took out a patent for his invention of the now well-known valve-closet.* I give an illustration of this water-

Bramah's Water-closet.

* Bramah's closet has been much improved upon by the various makers of the valve-closets of to-day, and though each and all may follow Bramah in the principles of his water-closet, there is hardly a bit of "Bramah" left in the valve-closet now made. I have had my share in its improvements, which others have not been slow to copy.

closet in Fig. 83, as taken from the drawing attached to the inventor's specification.

As you will see, by looking at the woodcut, the shape of the basin is very similar to Alexander Cumming's closet, referred to just now. The great advantage of Bramah's closet over Cumming's is that the former is made with a valve which *seats* itself against the bottom of the basin by a *cranking* arrangement, whereas the latter *slides* under the

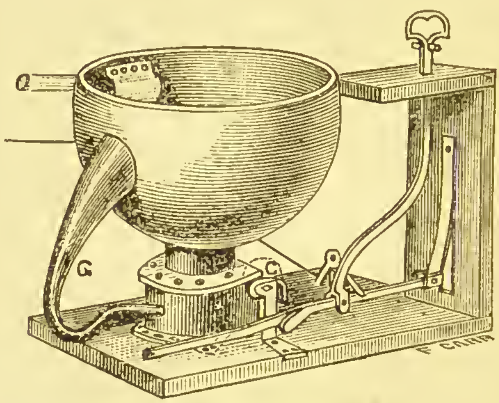


Fig. 83.—Bramah's closet.

bottom of the basin, as shown at *e*, Fig. 81. In his specification, Bramah says, "The valve is placed under the bottom of the basin, and when closed retains any water that may be therein, thus cutting off all smell." If Mr. Bramah were with us to-night—and I dare say he would not object if we only had Mr. Home's professed power of bringing him—he would be able to tell us some very interesting things in connection with the introduction of water-closets inside the houses of this country about a century ago. And we should be able to tell him

that though *he*, by his invention of the "Bramah" closet, tried to shut offensive smells *out* of closets, many inventors since, as well as many manufacturers of to-day, have tried their utmost, and succeeded well, too, in making closets which not only did not attempt to shut out any bad smells (for they had no "protecting" valve on their "outlets,") but which had large "containers" for generating and holding bad smells. And as he would, no doubt, want ocular proof of the insanity of such manufacturers making such an unsanitary fitting, I would show him this old pan-closet,* except that I should be afraid of losing him; for a man whose olfactory nerves were so sensitive that he could not endure a water-closet which allowed bad smells to come *occasionally* from it, would instantly disappear at the sight of this closet, which *always* sent out bad smells.

In Bramah's day, according to the wording of his specification, they were looking to water-closets to "shut out bad smells," whereas the foremost men of to-day are looking for closets to be *self-cleansing*, and to the drainage to be *wholesome*.

The difficulty in getting the "slider" (*e*, Fig. 81) of Cumming's closet, and the *cranked* metal-valve of Bramah's, to always seat themselves, so as to keep the basin always charged with water, and to stand rough usage, led to the introduction of the pan-closet.

* An old pan-closet, with all its dried excrement and corrosion upon it, was placed on the table for inspection.

Law's Pan Closets.

William Law, a founder in Soho, made certain improvements in pan-closets in 1796. But the pan-closet was not much used, though other improvements were made in it before the early part of this century. In 1826 William Downe, senr., of Exeter, also a founder, made further improvements in the pan-closet, "reducing the size of the *container*," etc. You see they gave this *excrement-holder* the right name, for it is not simply a receiver, it is a "container" too. The fact is, that when any foul matter is sent into the "container," it retains a part of it, which soon corrodes upon its sides, though it allows the larger part to pass freely away. You know the story of the lawyer. He had swallowed half-a-sovereign by mistake, but though his medical man used the pump very vigorously, all that he could pump up again was three shillings and four pence—the lawyer had assimilated the remainder, the six shillings and eightpence.

Pan-closet extensively used.

One reason why the pan-closet has had a larger sale, and been more extensively used than any other closet, is that there are no valves about it—apart from its supply—to get out of order. It will also stand rougher usage, when well made, than any other closet of that kind having water in its pan for receiving the discharge sinto it. But it is the most unsanitary water-closet that I know of, and ought never to be used.* I am

* Mr. Rogers Field stated, at the close of the lecture, that the use of the pan-closet was forbidden by the Local Government Board.

free to condemn this closet, for though nearly every water-closet maker makes them, it belongs to nobody in particular. We have every appliance and pattern for making pan-closets, and we have made thousands in our factory, and are making some at this very moment for one special job, for people will have them, but I never allow one to be made if I can help it.* We porcelain-enamelled the "container" part years ago, and have made that part in white ware, but no matter what the material is, it cannot be made a wholesome closet. The amount of dried excrement and corroded matter which can be cleaned out of an old pan-closet is about 2 lbs.; of course this varies, and may be much more or a little less. The exposed surface part of a pan-closet—leaving out the inner-side of its basin—which can, and which in use does, get foul is equal to about 5 ft., superficial measurement. Now if you set this against 10 or 12-in.† in a valve-closet you will see the evil of such a closet; and you have this fact in addition—namely, while this 10 or 12-in. of exposed surface in the valve-closet is easily washed, the 5 sup. feet in the pan-closet cannot be washed, for no water can be sent over its sides—N, Fig. 84, top, outer-side of the

* As I have been criticised for making pan-closets at all, it is only fair to say that not only do we not offer them for sale, we strongly condemn their use when ordered, and only make them under very special circumstances. I condemned this closet as strongly as I could in my book, "The Plumber and Sanitary Houses," years ago.

† The inner surface of the "valve-box," or "conductor" of my valve-closet, F, Fig. 89, is only 9-in. sup.

copper pan, O, and outer-side of the basin, dipping into the pan—with any cleansing force to cleanse it. And yet thousands of these unsanitary closets are fixed every year. I saw a large van-load of them going along Farringdon Road only a few weeks ago.

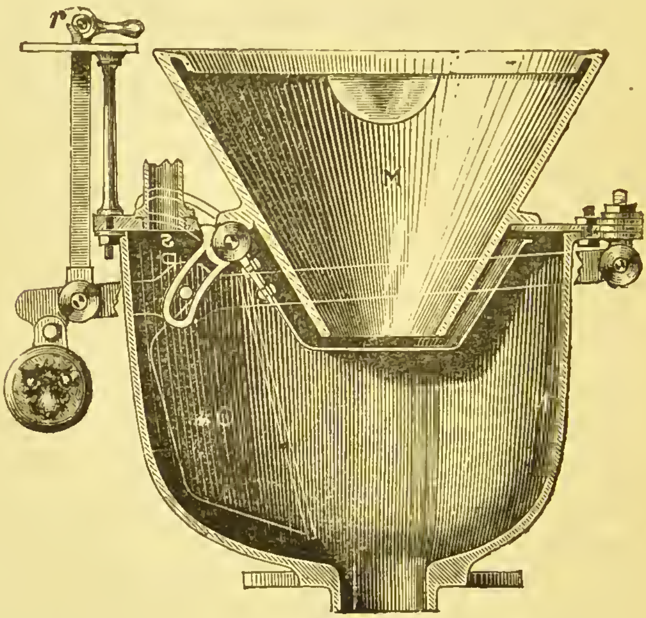


Fig. 84.—Section of a Pan-closet.

Other Closets Unsanitary.

But there are other closets besides pan-closets which are totally unfit for their work, but we have no time to examine them, for their name is legion I will, therefore, simply say—before passing on to consider the valve-closet further—that no water-closet should be fixed which will not allow a flush of water, of two or three gallons, to cleanse every part of it which can be soiled by usage. A flower-pot, with its bottom knocked out, placed over a self-

cleansing trap, fixed upon a well-ventilated soil-pipe, would made a much more wholesome water-closet than many closets now in use. The less exposed surface there is in a closet and its trap, the easier they can be cleansed; and unless such places

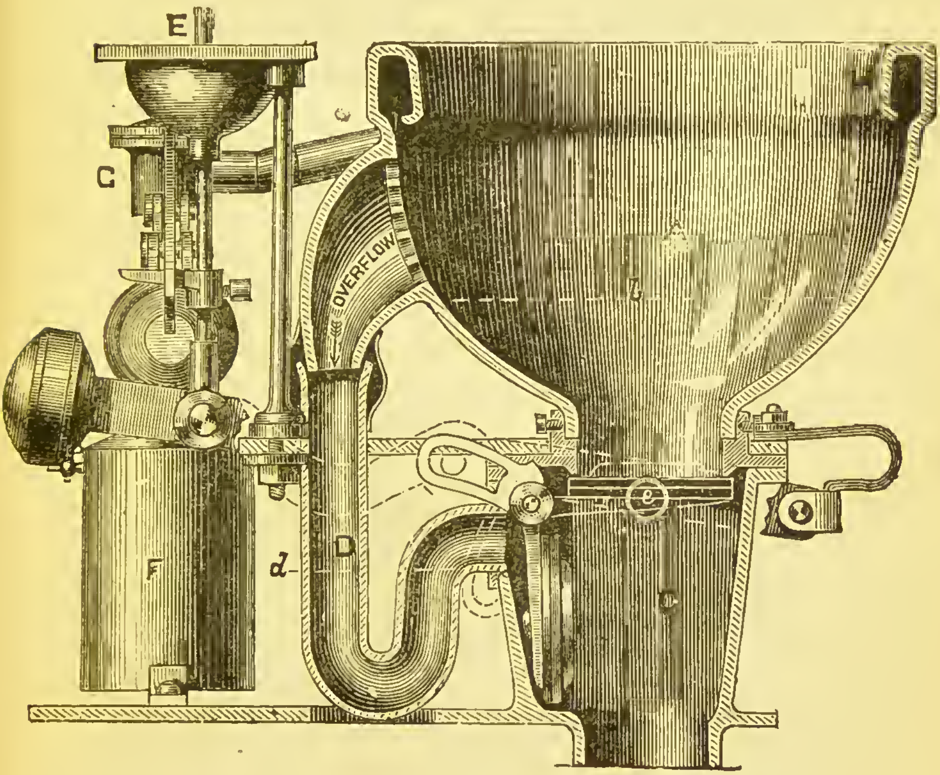


Fig. 85.—Section of a Valve-closet.

are *thoroughly* cleansed every time they are used, they must become unwholesome, and therefore sources of danger.

VALVE-CLOSETS.—Where cost is not a consideration, and in places where frost would not be Valve Closet.

likely to freeze the water standing in the basin, I consider a valve-closet the best water-closet to fix, especially when it is perfect in all its details. But good wholesome water-closets can now be fixed at a very small cost—closets suited to their purpose.

Valve-box Ventilated. The ventilation of the "valve-box" of a valve-closet is of greater importance than will be allowed

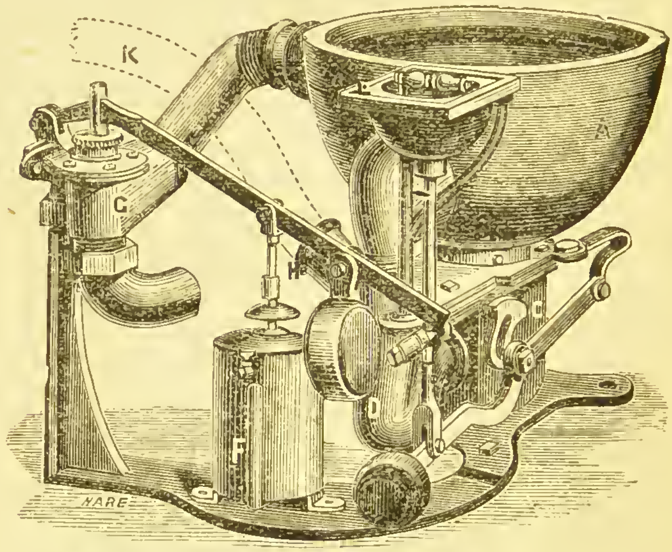


Fig. 86.—View of a Valve-closet, with Vent-pipe.

by many, and as the cost of this would rarely exceed fifteen shillings (including the cost of the vent-arm—$1\frac{1}{2}$-in. or 2-in. pipe, K,—to go through wall to the open air, cutting hole through wall and making good), it should always be done. In writing of the value of this air-vent, in the enlarged edition of my book, "The Plumber and Sanitary Houses," I said, "The ventilating pipe from the

'conductor' or 'valve-box' of a valve-closet is of great importance. (a) It allows the overflowing water of the basin to pass freely through the overflow-trap and the closet trap, as it gives the valve-box air. (b) It prevents the overflow-trap, D, Fig. 85, from being unsyphoned. (c) It provides an escape for 'noxious gases' which may be thrown off by an offensive stool left unwashed out of the closet trap,* or which may have worked their way through the water-seal of the trap through the imperfect ventilation of the soil-pipe." . . . "To abolish the overflow-trap . . and to fix a *separated* overflow-pipe, unless it is done with great care, may prove a remedy worse than the disease."† The closet would often be used without discharging its contents, and the liquid excrement would flow down the overflow-pipe and pollute it, and then, if it required a long length of piping to convey it away to a proper place of disposal, the pipe would want trapping, ventilating, and periodical flushing to keep it wholesome. There would also be danger from frost with such an arrangement,

Overflow separated.

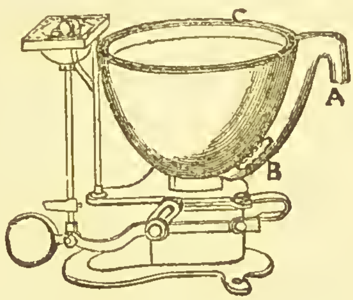


Fig. 87.—Valve-closet, Overflow separate.

* By a careless pull of the closet-handle.—In testing closet traps (see Table, No. 1, p. 160) we saw that it required several flushes to free certain traps of foreign matters sent into them.

† I had this done as far back as 1870, but it is only rarely that circumstances will fairly admit of such practice.

for the overflowing water would dribble through the overflow-pipe in a manner to freeze up the pipe in frosty weather. Fig. 87 shows my valve-closet with its overflow separate from the valve-box. The mouth of the overflow-arm, A, is kept well down under the water line, as shown at B, to prevent the cold air blowing through the overflow-pipe.

Overflow improved.

I have made some further improvements in my valve-closets—which I consider of importance. Servants *will* empty their slop-pails into water-closets, especially when there are no slop-sinks, and when this is done in a valve-closet, the basin is often filled up to the brim. In discharging a closet-basin so filled, the matter not only fills the "conductor," C, Fig. 85, but it flows and splashes right into the overflow-trap D, and fouls it; and then, rushing out of the conductor and through the closet trap, it *unsyphons* the *overflow-trap* (D). I have tested this a great many times, and rarely failed to unsyphon the overflow-trap, with no ventilation of the conductor. With the conductor ventilated, the overflow-trap is safe enough from syphonage. Now if a trap with $1\frac{1}{2}$-in. or 2-in. seal is easily unsyphoned, how much more easily must the overflow-trap of the general valve-closet be? The trap shown in Fig. 88, for instance, and scores of valve-closets are made with even less seal than shown there.

Overflow-trap unsyphoned.

Fig. 88. Overflow-trap, inefficient seal.

I have seen many with only $\frac{1}{8}$-in seal, and some with no seal at all. But though the ventilation of the valve-box prevents the unsyphoning of the overflow-trap, it does not prevent matter flowing into it. In Fig. 89 I show the overflow-trap, C, *discharging into the vent-arm of the conductor* F,—which is specially lengthened

Overflow into Vent-arm.

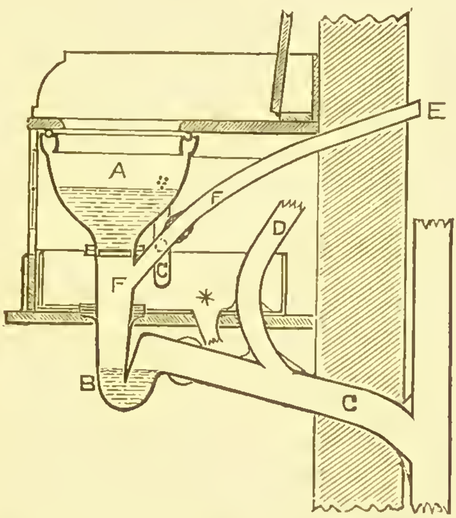


Fig. 89.—Section of Valve-closet, with Overflow-trap emptying into Vent-arm.

to receive it ; this keeps the outlet of the overflow-trap well above the valve-box, and being connected with the air-pipe, E, from the conductor it cannot be unsyphoned, while, at the same time, no foreign matter can wash up into it. To ensure this trap being charged every time the service-valve is opened, a water-channel is formed between the inlet-arm of the basin and the overflow-arm ; or, in other words, a feed-pipe is formed in the

basin itself, for conducting a stream of water direct from the inlet-arm of the basin into the overflow-trap. This small stream of water not only charges the overflow-trap, but it washes out any matter which, in a discharge of a full closet basin, might get splashed up into the vent-pipe of the conductor.

Variety of Closets.

It would occupy several evenings to put before you the merits and demerits of the great variety of water-closets now in use; but I do not intend to point to any man's make, nor to bring my own before your notice, for when *self-interest* comes between a man's eye and any object, it interferes with its true proportions. It is like a piece of bad glass in a window, through which he looks at the outside prospect; everything is marred and distorted by it. Let me give you an illustration. I was looking through a window the other day, on to the new building now being erected in the Inner Temple, and I said to myself, "What crooked scaffold poles!" In fact the flaw in the pane of glass through which I was looking formed a piece of one of the horizontal poles into a syphon trap. I thought I must be getting traps on the brain; but there was no doubt about the effect of the bad glass upon the object, for on coming outside I found the pole to be as straight as a gun-barrel. What I ask for is that no water-closet shall be fixed which will not allow itself to be *thoroughly cleansed*, and its traps well washed out every time it is used, and that too by one pull of the closet-handle.

Having said so much on water-closets, and in an earlier lecture laid down the principle on which traps for fixing under them should be made, I now come to the question of soil-pipes from them, for we have already considered the necessity of having traps under all sanitary fittings. (See Fig. 93, Plate VII., showing traps fixed for receiving valve-closets). To give plenty of room for clothes the centre of the dip or inlet of the trap should be kept 16-ins. at least from the face of the back wall. (See Fig. 89, showing wide margin at back of hole in closet seat for clothes.)

SOIL-PIPES.—I will divide this subject into five heads, namely, 1, Materials—their sanitariness and durability; 2, Sizes; 3, Positions—shall they be outside or inside? 4, Disconnection from drains and their ventilation; 5, Tacks for securing lead soil-pipes in their positions. Soil-pipes.

1. Of what *material* should soil-pipe be made? This may seem a curious question to ask of plumbers—as well ask a shoemaker of what material should boots and shoes be made! Everybody knows that the latter would say "There's nothing like leather," as the former is sure to say "There's nothing like lead." But I want to look at this question from a higher platform than trade interest. What is the *best* material—when you have skilled labour at command, and taking everything into consideration—for soil-pipe and "dirty-water" waste-pipes? Material.

Lead. Allowing experience to be my schoolmaster, I answer *lead*—especially for our climate.

Zinc. I will not insult practical plumbers by comparing such perishable material as zinc with lead—though zinc * soil-pipe is sometimes used in what are called "jerry-buildings."

Earthenware. Nor will I waste words in comparing lead soil-pipe with earthenware or stone-ware pipes, for though the latter may be more durable, the soundness of its jointings could not be relied upon for an hour. And then there would be the difficulty of making sound connections with the W.C. branches or water-closets themselves; and though the pipe itself might be somewhat cleaner than lead, the sockets would form ledges for filth to accumulate upon. The bulkiness of the pipe, with its huge sockets, precludes it from being fixed outside a house; and to fix such pipes as stoneware inside, or in a chase in the wall of a house for soil-pipes, ought to render a man actionable at law.

Cast-iron. The only material that comes into fair competition with lead for soil-pipe and waste-pipe is cast-iron, and I give lead the preference, because it is more durable, more compact, and more wholesome. I do not say lead because of any fear that if cast-iron soil-pipe got into general use it would injure the trade; for if the plumber can fix lead soil-pipe, which requires the greater skill—on account of its "purpose-made" bends,

* Professor Corfield, at the close of the last lecture, said he had an old zinc W.C. D-trap, in the Parker Museum.

and wiped soldered joints—he can certainly fix cast-iron soil-pipe which requires the lesser skill; for the bends and socket-branches in the latter case would be cast for him and ready to hand; and as for the jointings, he would have no difficulty whatever in making them, whether (as in the case of light iron pipe) they were made with spun-yarn and red lead, or in "cement," as shown in Fig. 90, or whether the joints were caulked

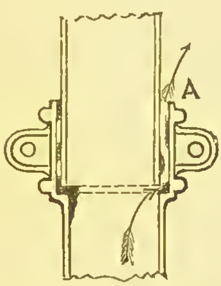


Fig. 90.—Section of defective jointing.

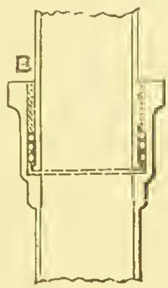


Fig. 91.—Section of a caulked lead joint.

with lead, as shown in Fig. 91, as they most certainly should be, when the strength of the iron pipe would admit of it. No cast-iron soil or waste-pipe should be fixed inside a house that would not allow the joints to be made of *lead* and well caulked, for no dependence can be placed in *cement* joints; the cement soon perishes or breaks away from the piping, and makes an opening for the soil-pipe air to escape through, as shown by the arrows at A, Fig. 90.

Cast-iron soil-pipe not only deteriorates from within by the corrosive action of urine upon it,

&c., but it also deteriorates from without, by the action of the atmosphere upon it—and this takes place whether it be inside or outside a house. We talk sometimes about the short life of a candle when it is burnt at both ends: well, here is a material which in use gets eaten away on both sides—inside and out.

Cast-iron soil-pipe, therefore, cannot be so durable as lead which, practically, is only acted upon on one side—in soil and waste-pipes, viz., the inside—and that to a much less extent than cast-iron pipe. What the atmospheric action upon cast-iron pipes is, let the London painter say. If iron pipe is painted periodically, it may be made to last a long time, but this involves a constant outlay of money, and if not an uplifting of voices, it does of ladders. But when such pipes are painted the back part of them is only partially protected with paint, for the painter's tool cannot reach round the pipe. The action of rust is not always arrested by painting an iron pipe, and this goes on underneath the coating of paint like many other evil things under the coatings of cloth.*

Lead Soil-pipes.

If two stacks of soil-pipe were fixed side by side on one of our London houses, one of lead and one of cast-iron (and wrought-iron would be worse), the iron pipe would decay and rust away before the eating-tooth of time had made any great impression upon the lead pipe. Lead rain-

* If *cast-iron* soil-pipes and waste-pipes are to be used, they should be protected by the Bower-Barff rustless process.

water pipes and heads can be seen by the dozen on many old mansions about the country to-day, though fixed centuries ago.

These lead pipes are more *wholesome* than iron, for the corrosion being greater on iron than on lead, the accumulation of filth upon them is greater too. In lead pipes, where there is good flushing, the corrosion is very little—except urinal wastes. A film forms itself upon the sides, but the friction upon it of a good scouring flush of water causes this film to fall off, and a lead pipe may be fixed for years without getting more than a slight thickness of corrosion upon it. It is also cleaner at the jointings (see Fig. 90, and compare it with Fig. 2).

Unskilled Labour and Cast-iron Soil-pipes.

Where plumbers are not skilled in pipe-bending and joint-wiping, it would be preferable to use cast-iron soil-pipe. Cast-iron has this advantage over lead that a carpenter cannot drive a nail, brad-hole, or gimlet into it, and when a soil-pipe is fixed inside a house it is worth something to the occupant to know that. Then, again, when the waste-pipes from baths and sinks are taken into a soil-pipe as in the United States, it is better to have cast-iron, for the action of hot water upon thin lead soil-pipe is very injurious—unless slip-joints are used to allow for expansion and contraction, but, of course, it would not do to fix soil-pipes, or waste-pipes, inside a house with slip-joints.

Lead soil-pipe is more compact than iron, and

it has this advantage also in that it can be bent on the spot to suit circumstances. Astragals, and ornamental lead tacks, can be soldered to it in a way which shall help the general appearance of a building rather than mar it.

Size.

2. THE SIZE OF SOIL-PIPES.—About fifteen or twenty years ago, it was common for plumbers to fix (under the direction of a specification) a 6-inch soil-pipe when it had to take the branches of four or five water-closets; and with many of the architects and builders, as well as the plumbers, of to-day, 5-inch and 4½-inch are the general sizes, and that too for only one water-closet.

Now, as it is of the utmost importance that a soil-pipe should be efficiently flushed out with water every time a water-closet upon it is used, it is evident that the smaller the size of the pipe the more efficiently will it be flushed; and as it is not wanted for a coal-shoot, or a dust-shaft, I cannot see why it should be so much larger than the *outlet-way* of the water-closet into it. In private houses, where the water-closets would be used with greater care than in public buildings, I consider 3½-inch lead soil-pipe quite large enough to take a *tier* of three or four water-closets—I am supposing the soil-pipe to be ventilated at top and bottom, and each trap or branch ventilated as well. I consider that 4-inch soil-pipe, when of lead, and made by hydraulic pressure, large enough to take the branches from several more

w.c.'s; and that 4½-inch soil-pipe is ample to take a tier of six or seven double closets, fixed over each other in a seven-storied building, for though many of them might be used together they would not be discharged precisely at the same moment of time, and one or two seconds would suffice, in a vertical soil-pipe, for the discharges to keep clear of each other; and if they did mingle it would not so much matter so long as the traps, by efficient ventilation, were made proof against any disturbance that could take place by the simultaneous use of all the closets upon the piping. I have had 3½-inch lead soil-pipe fixed to the tiers of three and four water-closets, but have never known the smallest inconvenience from such an arrangement, while the pipes, as far as I have been able to see, have kept cleaner than 4½-inch soil-pipes near them—*i.e.*, under the same conditions. In public buildings—as warehouses, hotels, banking houses, stations, club-houses, &c.—the soil-pipe ought, perhaps, to be larger, say 4-inch, but I consider 4-inch (or 4½-inch) large enough for any place and for any number of closets.

In many places, with efficient water service, 3-inch soil-pipe might be fixed for single water-closets without any risk of stoppage.*

* Some months ago I had a *stack* of 3-INCH lead soil-pipe fixed in my factory to take the branches from *three* water-closets—a valve-closet, a "vortex," and an "artisan"—and the size is found to be quite large enough, though the closets are rarely ever idle during the working-hours of the day. This arrangement is illustrated in Fig. 67, Plate V., p. 168.

Positions—Inside or Outside.

3. THE POSITION OF SOIL-PIPES. Are they to be outside or inside? I give my voice in favour of *outside.* I would not pull down a house and re-build it to get the soil-pipes in it outside; but wherever it is at all practicable, and in all new houses, I would insist upon the soil-pipe being fixed outside, unless special circumstances called them inside, and this would, no doubt, be the case in some instances. But what about frost? Well, there is no danger of that if you keep the water out of it, any more than there is of a gas explosion in the room if you keep the gas turned off. Allow a faulty pipe or gas-cock to leak the gas into a room, and then come into it with a lighted candle, and where are you? I should say in the street—*i.e.*, all that is left of you. Allow the closet-valve to leak water into an *outside* soil-pipe, when Jack Frost is on the alert to arrest it, and where is it? why, imprisoned in the pipe of course. But keep the water from leaking into the pipe, and there will be no risk of freezing. There is also much less risk of freezing when the discharging ends of such pipes are carried down below the ground level, out of the way of the cold sweeping winds, as shown in Fig. 93, for when the ends of such pipes are more exposed, the wind catches the dropping water and freezes it until it has completely corked up the end of the pipe, and then in time the whole of the piping becomes a block of ice.

Rain-water and Soil-pipes.

It is also an evil to take rain-water into soil-

pipes, especially outside pipes, for it often happens that the sun melts a little snow near the head of a rain-water pipe, and this snow-water trickles down the pipe, where it soon freezes and stops up the soil-pipe.

Outside Soil-pipes and Frost.

In the sharpest frost in this country there is not the smallest fear of the legitimate use of a water-closet ever stopping up an outside soil-pipe with ice. The discharges through such a piping are too quick for freezing. When soil-pipes are fixed outside, in bleak positions, however, I *prefer* them to be put into chases, with iron-plates in front of them to look like iron rain-water pipes, for better protection.

I have had our books looked through, and find that in the three years preceding the present year (1881) we fixed just 130 stacks of soil-pipe *outside* (or a total length of about 5,000 ft.) and I have not heard of one of them being frozen. It is really a question of good supply-valves to the W.C.'s, and if these are looked after, there is no danger from frost. I have a stack of soil-pipe outside my own house, which faces north-east, and though the closet valves upon it have not been touched for four or five years, there has never been the smallest inconvenience from frost, or any other thing, and the pipe is open to the atmosphere both at the top and bottom.

Effect of Heat upon Pipes.

The effect of frosty weather upon outside soil-pipes—when no water is allowed to leak into them —is not so damaging as the action of the sun

upon them when they are fixed in certain positions; for they would often be exposed to the direct rays of the sun for many hours together, and the effect of this would be to stretch the lead pipe between the "tacks," and this stretching would go on from year to year bending the pipe out of its true vertical line, and perhaps breaking it. Where "slip-joints" can be used, such lead pipes, when they are properly ventilated to prevent the action of gases upon them, will last for centuries; but where the joints must be soldered, to prevent soil-pipe air escaping through them into the windows of the house, &c., such pipes should be kept in an angle, or placed where they are likely to be most screened from the rays of the summer's sun.

Heat causing Air-currents.

There is another important reason for keeping soil-pipes out of the sun, for the air in such pipes would get so rarefied that the air-currents through them (where they are ventilated at top to bottom) would be so great that the excremental discharges would partially dry upon the pipe, especially when the water-closets were used with little water. When soil-pipes are exposed to the sun in the way we have just been considering, they not only get warm, but they get quite *hot*, and unless a body of water is sent through them by pulling the closet-handle before using the closet (a good thing always), a portion of the discharge would be likely to dry upon the piping, which may

be a long length, and foul it. This argument tells also against *inside* soil-pipes, though not with equal force, for though soil-pipes fixed inside a house would generally have greater currents of air through them than soil-pipes fixed outside (on account of the warmth of the house) they would never get so hot as soil-pipes exposed to the sun. But all that is wanted in outside soil-pipes is to keep them out of the full power of the sun's rays; for good air-currents—with efficient ventilation—can be made to pass through soil-pipes though fixed in the coldest quarters—at any rate sufficient to aerate them.

Soil-pipe Air.

The risk of getting soil-pipe air into a house is so minimised by fixing soil-pipes outside, that it is worth running the small chance of freezing from a leaky valve; which casualty ought never to be allowed to remain for a single day, winter or summer; for dribbling waters will not cleanse a pipe, though they may drain a reservoir and prevent proper flushing when needed.

When the soil-pipe is kept outside the house there is no risk of the air in it leaking into the house, either through a nail-hole—made in the pipe by accident; a defective jointing—when fixed by an unskilled man; or from decay of the pipe through old age.

Ventilation of Soil-pipes.

4. VENTILATION OF SOIL-PIPES AND THEIR DISCONNECTION FROM DRAINS.—I believe air-pipes were first fixed on the tops of soil-pipes

about sixty or seventy years ago, except where such pipes received rain-water pipes, when they would probably be of one size throughout.* It is quite possible to find soil-pipes fixed within the last ten years without any air-pipes, but in good plumbing jobs air-pipes were fixed from the top of the soil-pipes at least forty years ago. The sizes of such soil-pipes varied according to the different ideas of the value of such pipes. Some fixed ½-in. and some 2-in., but I should say the average size (where such pipes were fixed) then was 1¼-in. I know of stacks of soil-pipes 5-in. and 6-in. in diameter fixed from fifteen to twenty years ago with only 1½-in. air-pipes on the top of them, though there are half-a-dozen water-closets discharging into each stack. The custom in all good works now is to carry the soil-pipe up *full-size* above the roof for ventilation; at any rate it is done in every job where a sanitarian has the direction of the plumbing and sanitary work.

It is so good a rule that I am afraid to say the smallest word in disparagement of it; but it sometimes happens that a water-closet is wanted on the ground floor of a very high building, and it does seem an expensive arrangement to fix 50 ft. or 60 ft. of 4-in. air-piping to ventilate a 7 ft. or 8 ft. length of 4-in. soil-piping. In such a case I should fix 3½-in. soil-pipe, disconnect the

* I have seen a drawing of a water-closet, made in 1820, with the soil-pipe from it taken into a rain-water-pipe, and the rain-pipe going up to the roof *full-size*.

soil-pipe from the drain, or give it "foot-ventilation;" and if windows would not allow me to terminate the air-pipe just above the soil-pipe, I should be satisfied with a 2-in. air-pipe going up to the roof—ventilating the trap of the W.C. into it with a branch-air-pipe and using a "V-dip" trap to prevent syphonage. When the soil-pipe does not exceed 6 ft. or 8 ft. in length, and is *dis*-connected with the drain at its discharging end, so that the atmosphere can pass into it, and provided that the water-closet fixed upon it is well supplied with water, there is no necessity to fix a long length of air-pipe on the top, unless windows compel it; but with such a pipe, open at both ends, and well flushed with water, there will be no offence* from it, so long as the "outlet" of the air-pipe can be kept about 8 ft. or 10 ft. away from any window, or opening, into the house.

All soil-pipes should be continued up full-size, except in very special cases, and the tops of such pipes should be kept well above all windows and openings into the house. I know of cases where ventilating pipes from soil-pipes and drains have terminated at such ill-considered points, that the offensive air from them has been blown down the chimneys into the rooms of the house. How often as one rides about London can such pipes be seen stopping just under a cornice, where there is no wind to blow away the bad air emitted from such

Air-pipe, size of Soil-pipe.

* This arrangement has been tested in actual practice and it answers admirably.

pipes; or they are just bent up over the eaves guttering where the air escaping from them can easily get into the house between the slates or eaves; or they are carried up to the ridge of the roof and terminated within a foot or two of some skylight; or they are taken up the face of a dormer and left standing a foot above its doorway or window (see Figs. 120 and 121). The ends of such pipes should be kept as remote as practicable from all places from which the air coming out of them could come into the house.*

Soil-pipes badly Ventilated.

As a general rule soil-pipes are fixed, even in these enlightened days, with inefficient ventilation. An air-pipe on the top of a soil-pipe—no matter what may be its size—will not ventilate it any more than a chimney will ventilate a room with its windows and door closed. You may ride hundreds of miles in a railway-carriage at times with one window down without feeling much wind, but open both windows—and you would not care to ride a mile unless you had a bottle of Bunter's Nervine in your pocket. To get a current of air in pipes they must be open in some way at both ends, and without a current of air in pipes—soil-pipes, waste-pipes, and drains—there is no efficient ventilation; and without good ventilation such pipes cannot be kept wholesome, nor are they free in such cases from the action of gases upon them.

A simple experiment was given to show that without foot-ventilation no pipe is properly ven-

* See Figs. 70 and 93.

tilated. A glass tube, illustrated in Fig. 92, representing a stack of soil-pipes, trapped at the bottom, D, was filled with smoke, but the smoke would not rise out of the tubing, though the top end, A, was quite open. An opening was then made near the bottom of the tubing, by pulling out a cork fixed at B, and the smoke instantly rose and passed out of the pipe at A. The removal of the cork B gave it "foot-ventilation," and a current of air at once passed through the piping. [There was a little hitch in this experiment on the re-delivery night, but this was caused in filling the tubing with smoke by the heat from the smoke-paper on the brass connection, B. This warmed the lower part and drew the current downwards.]

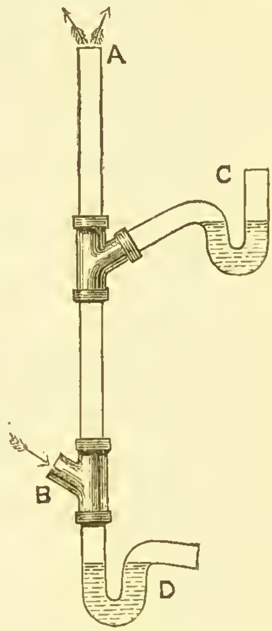
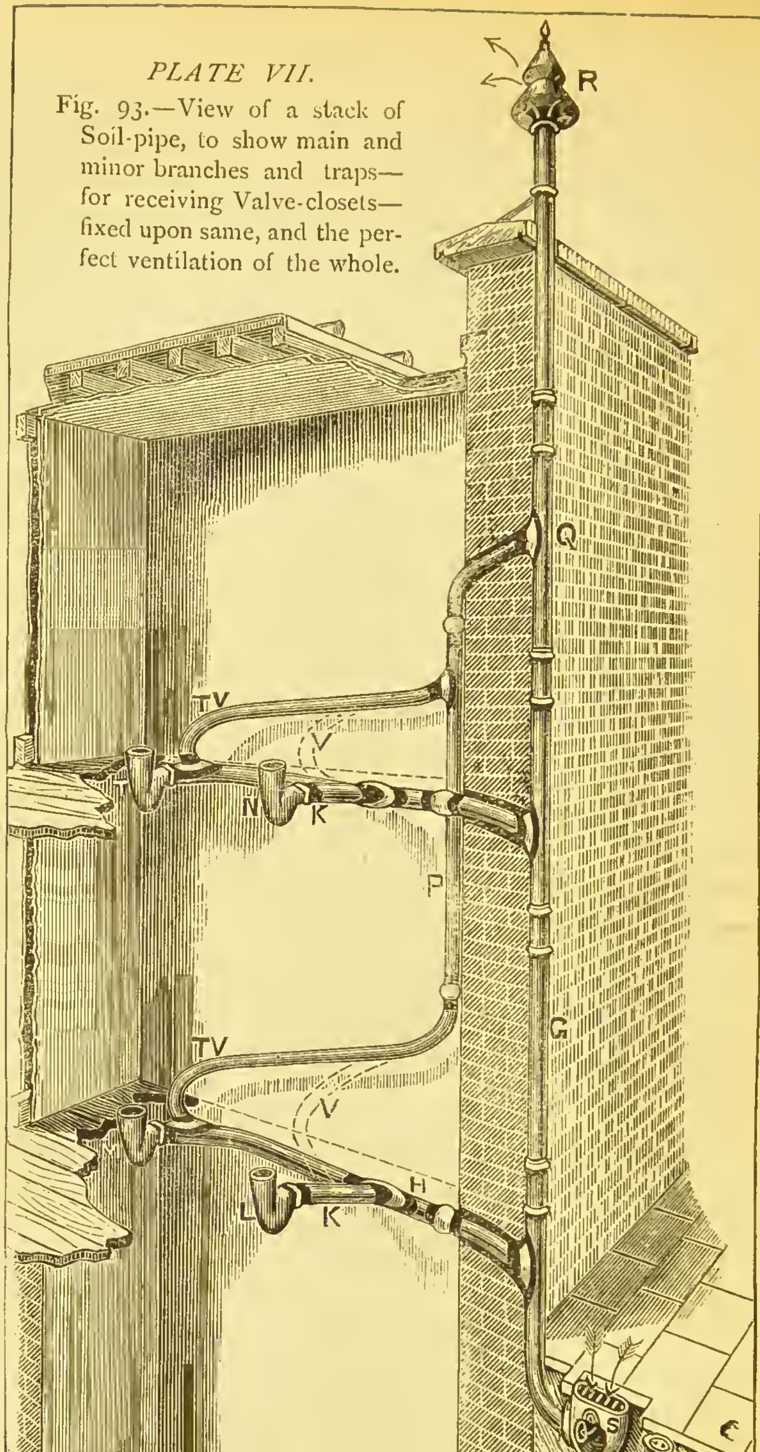


Fig. 92.—View of Glass Model.

I hope I have clearly proved the necessity of exposing both the upper and lower ends of a stack of soil-pipe (or waste-pipe) to the atmosphere, if it is to be properly ventilated. To make what I have said on the ventilation of soil-pipes and traps better understood, I have illustrated, in Fig. 93, a perfect system of ventilation. There are two tiers of traps shown for receiving valve-closets, but of

PLATE VII.

Fig. 93.—View of a stack of Soil-pipe, to show main and minor branches and traps—for receiving Valve-closets—fixed upon same, and the perfect ventilation of the whole.



course any number could be added to meet the wants of a six-storied building; and instead of two water-closets on each tier three could be fixed, or only one, as circumstances required, by adding to the length of the branches, or shortening them.

The minor branches, K, from the traps L N, are branched into the sides of the chief branches, H, in such a way that the discharges through them shall not foul any part of the soil-piping which would not be cleansed by a fair flush of water following such discharges, and the outer traps, M T, are soldered direct on to the bent ends of the chief branches for the same purpose. The chief branches are nosed downwards at the junction with the main soil-pipe to prevent any matter passing through them splashing and soiling any part which would not be cleansed by the flush of water following the discharge.

The soil-pipe, 3½-in., is carried up full-size, with an extracting cowl on top, as shown at R, and it is disconnected from the drain, by the soil-pipe disconnecting trap S, and its discharging end open to the atmosphere for perfect ventilation of the pipe.

"Small" "Anti-D-traps" are fixed for receiving valve-closets, and the *chief* branches are ventilated, as shown at T V, to prevent any disturbance of the trap "seals" by discharges through the piping from any of the closets, and, also, to

prevent* stagnant air lodging in any part of the branches. As far as syphonage is concerned, it is not necessary to ventilate the short branches from the traps L and N as shown by the dotted lines V.

The ventilating-pipes are fixed in such a way that nothing foreign shall get into them to stop them up, and they are so connected with the branches from the traps, as shown in the woodcut, that the air-currents through the piping shall not play upon the "standing-water" of the traps to disturb it, or to lick up any of its water in its transit through the pipe. This is important, as a current of air constantly passing over the water of a trap would, under certain circumstances, absorb enough water to seriously affect the seal.

Disconnection of Soil-pipe from Drains.

Whether soil-pipes are fixed outside or inside a house, they should in every case empty themselves into the drain *outside the house;* and, if at all practicable, they should have their discharging-ends exposed to the atmosphere, as shown at S, Fig. 93. Fig. 75, p. 180, shows a "soil-pipe disconnector," for receiving soil-pipes and intercepting them from the drain. There need be no fear † of any offensive

* The advantage of trap-ventilation is much greater than many people seem to know, for they are anxious to find traps which need no ventilation. The ventilation of the trap not only prevents any disturbance of its seal, it provides an escape for any bad air thrown off from a stool left in the trap, by a careless pull of the flushing (or closet) handle. It also preserves the piping and trap from the injurious effects of stagnant soil-pipe air.

† I have had stacks of soil-pipes, with several water-closets upon them, opened to the atmosphere at the foot, as shown in the

smell coming through the grating of the trap, F, Fig. 75, or S, Fig. 93, provided that the traps fixed upon the soil-pipe are of a self-cleansing nature, and that the closets have an efficient supply of water for keeping the soil-pipes wholesome.

This soil-pipe-trap, or disconnection-trap, Fig. 75, should, however, be kept some little distance

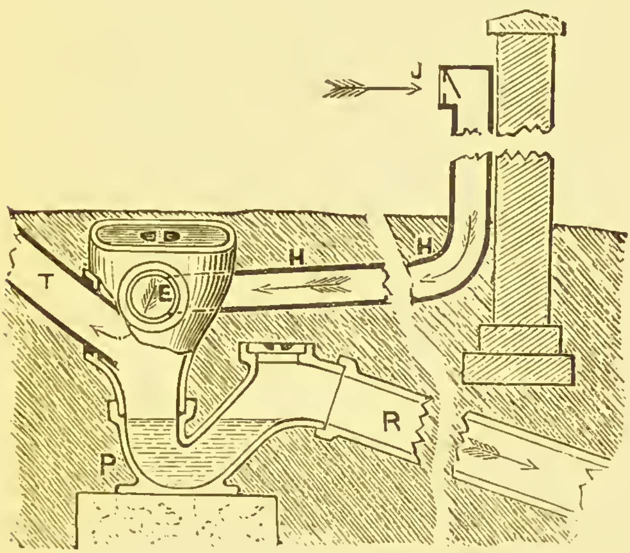


Fig. 94.—"Soil-pipe Disconnector," with "Foot-ventilation" and Mica-valve, J.

away from windows, doors, and openings into the house, and the disconnecting-trap itself should be self-cleansing.

When such traps, from force of circumstances, would have to be fixed immediately under a

illustrations, Figs. 93 and 96; and though the drain disconnecting traps have been fixed where there is great passenger traffic, and thousands of people have walked on the gratings over such traps, I have never heard a single complaint against them.

P 2

window, or in a small area, or *close* to a doorway to the house, the *top* of the trap, F, should be *sealed* over, by bedding down a cover upon it, as shown in Fig. 94, and a fresh-air induct-pipe should be taken into the inlet side of the trap, at D or E, to give the soil-pipe "foot-ventilation," as shown at T and H, Fig. 94, with a grating or mica-valve—as

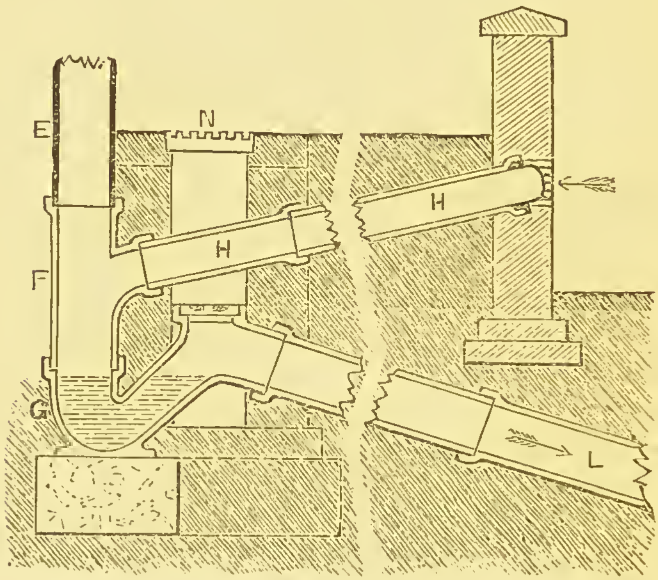


Fig. 95.—"Soil-pipe Trap," with "Foot-ventilation."

at J—over its mouth. That part of the pipe fixed underground should be of stoneware. Or the soil-pipe can be disconnected by a trap, as Fig. 95, in places where the air, driven out of the soil-pipe by the discharges through it, could not readily get away (if allowed to escape out of the soil-pipe) as would be the case with such *open traps*, as Figs. 75 and 96, when fixed in deep areas, or places en-

closed with high buildings all round. But with the mouth of the induct, H, carried away to some convenient place, as shown at I, Fig. 95, there would be no chance of any air coming out of the soil-pipe and into the house.

In places where such open traps, as Fig. 75,—and as shown fixed in Fig. 93,—would be exposed

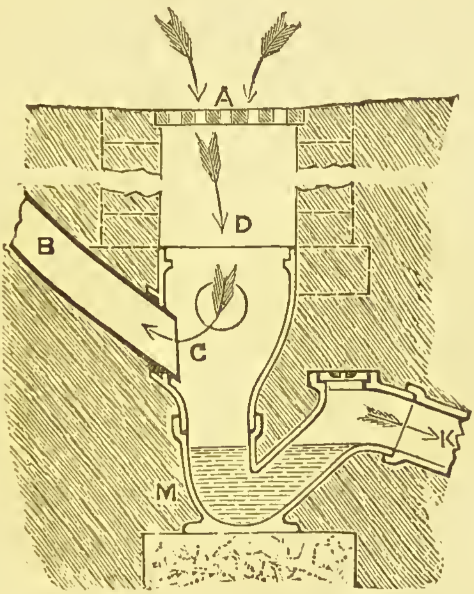


Fig. 96.—Section of Soil-pipe Disconnector, with Air-shaft.

to severe frosts, keep the trap down into the ground, as shown in Fig. 96, for the water of the trap to stand a foot or two below the surface, and build up an air-shaft, as shown at D, with a grating over the top, as shown at A, for the free admission of fresh air into the soil-pipe B.

5. LEAD TACKS, FOR SECURING SOIL AND WASTE-PIPES, ETC., IN THEIR POSITIONS.—We Tacks to Soil-pipes.

have not much time left for "tacking," but as pipes will not hold themselves in their places any more than ships without anchors, I must say a few words on *tacks*.

I suppose a man would rather have one ear pulled than both, but if he had to be suspended in the air by such means he would prefer both ears used. Now when a soil-pipe is hung up by "single" tacks it is not so secure, nor so durable, as when *pairs* of tacks are used.

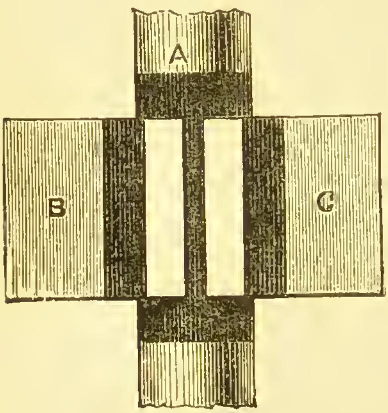


Fig. 97.

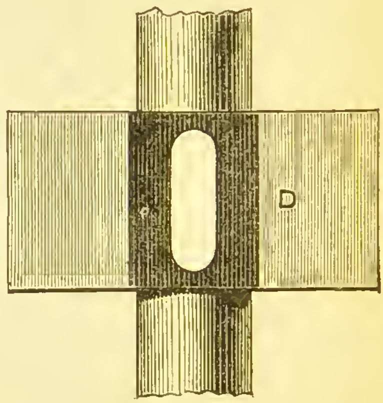


Fig. 98.

A pair of tacks, as illustrated at B and C, Fig. 97 (looking at the tacks as they are soldered to the back of the pipe, A) have double the strength of a single tack, for they have twice the surface-holding on the piping that a single tack has. They are also much stronger than a "double-tack," D, Fig. 98; for they have a greater grip of the pipe, as may readily be seen by comparing the two arrangements (Figs. 97 and 98), the surface-

soldering on the pipe being about two-thirds less on the *double-tack* than on the *pair* of tacks.

Single tacks, as Fig. 99, give a one-sided look to soil-pipes, when they are fixed in sight, and suggest how the sailor must have looked with his face shaved on one side only, and his razor at the bottom of the sea.

Tacks for soil-pipes, ventilating-pipes, &c., &c., should be cut out of sheet-lead of a stronger substance than the pipe—say 1 lb. to the superficial foot heavier. For outside soil-pipes with astragal jointings,* a pair of tacks, 9-inch by 8-inch, should be soldered to each 6-feet length of piping—or two pairs to a 12-feet length of soil-pipe. When soil-pipes are fixed inside, single tacks can be soldered to the pipe, alternately — right hand and left hand. These tacks should be about 10 inches by 9 inches, so as to get three wall-hooks in them, if fixed against brickwork—as shown at Fig. 99.

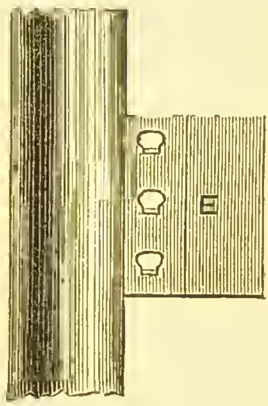


Fig. 99.

The wall-hooks for securing the tacks to the wall should be driven in nearer the piping than the folded edge of the tack, and the tacks should always be folded back so as to fit nicely against the pipe, well covering the heads of the hooks.

The whole of the tacks, for fixing on one stack of

* See Fig. 19, p. 55.

soil-pipe, should be cut out together, so as to ensure their being of one size, and also for quickness; and after "feathering" one of the edges with a rasp, for fitting against the side of the pipe, each tack should be soiled about 3 inches in on the soldering face, and an inch on the opposite face. The tacks should then be shaved for soldering. The shaving should be about an inch wide, and a corresponding length and width should be shaved on the pipe, after soiling it. The tacks should all be fitted on the pipe, so that they may be soldered on in one heat. In soldering on a pair of tacks, as shown on Fig. 97, pour the solder on each alternately, and then wipe them quickly one after the other. Your mate should be ready with his knife to cut off the ragged edges of the soldering, and to square it with the edges of the tacks—or the plumber can do this himself. Some plumbers manage to solder on tacks very well without an iron, but others prefer an iron.

A word or two to encourage the use of tacks on small *air* and *waste* pipes. When wall-hooks, or pipe-hooks, are used for securing such pipes in their positions, the head of the hook is driven well against the pipe to bite it, and in doing this the pipe is often flattened and its bore reduced, as shown at B, Fig. 100. Where this occurs, the value of the piping for its work is depreciated accordingly.

FACE-TACKS.—When such pipes are fixed

against wood-work, a narrow strip of lead, about 1½ inches wide and 7 inches long, soldered to the pipe—with the face of the soldering in front, and looking like a piece of angle soldering—looks very neat, and makes a strong fixing, with, say, three brass screws in it securing it to its place. (See A, Fig. 100, showing such a face-tack.)

I also prefer such "face-tacks," or "soldered-tacks," to wall-hooks, for fixing certain service-pipes, as well as to air and waste-pipes, especially when such pipes may want removing to get at the "fittings" (as pipes from w.w. preventing cisterns to w.c. basins), for the screws can be easily taken out and the pipe removed without any damage to the surroundings.

Fig. 100.

America.

WASTE-PIPES.—In America the soil-pipe is the general conduit for receiving the discharges from baths, sinks, lavatories, &c., as well as from water-closets. But our climate is so much more favourable for the *open-pipe* pipe system, that we can afford to separate the various wastes without danger of frost, and expose their discharging ends to the atmosphere.

Waste-pipes into Soil-pipes.

There is no reason, however, why waste-pipes* from slop-sinks should not be branched into the soil-pipe when the proper class of water-closet is fixed on them, *except where hot water is laid on to*

* See Slop-sink Wastes, p. 239.

the sinks—for careless servants sometimes allow the hot water-tap to run to waste—to reduce the temperature of the water, &c.; and a body of hot water sent through a lead soil-pipe, followed by a pailful of cold water, would soon damage the piping. If the pipe could be fixed with *slip socket-joints*, as it could on the external face of a sheltered outside wall, where there were no windows or openings into the house, for any air which might leak through the jointings to come into it, there would be no danger of hot water doing much damage to the pipe, for expansion and contraction would then be provided against, in the slip socket-jointings of the pipe.

Waste-pipes generally.

Having said so much on soil-pipes, I must say little on general waste-pipes, but I must say something, or my subject will be incomplete.

To get good water flushings through such pipes for receiving the waste discharges from small lavatory basins, flat-bottomed sinks, and such like "fittings," the pipes from such "fittings" should be kept as small as practicable. But instead of reducing waste-pipes to very small sizes, to get good water flushes through them to cleanse them, it is better to increase the entrance-way into such pipes—as I hope to explain more fully later on—for if waste-pipes were fixed of too small a size, as $\frac{3}{4}$-inch or 1-inch, there would not only be a risk of stoppage in them, but such pipes would be of no value for cleaning out its "intercepting-trap" with the drain; and no flush of water could be sent

through such pipes for cleansing the branch-drain into which they discharged themselves—though this may, and would often, be the only means that such pieces of drainage had of being cleansed.

Waste-pipes and Frost.

There is another reason why such waste-pipes should not be too small—namely, the smaller they are the more likely they are to get frozen in frosty weather. This is also a reason for fixing waste pipes from sinks, baths, and lavatories *inside* the house, for the supply-valves to such fittings are often left dropping, or leaking, and the water from them, dribbling through the pipes, would soon get frozen if such pipes were fixed outside the house. Such pipes should be fixed in easily accessible chases, *inside* the house.

Waste-pipes too large.

But the general fault is not in fixing waste-pipes from lavatories, &c., too small, but too large. Wash-hand basins, with ¾-inch plugs-and-washers, are fixed upon 2-inch syphon traps, and 6-inch D-traps, having 2-inch waste-pipes from them. Baths with perforations over its outlet-waste only equal to the area of 1¼-inch pipe are fixed upon 2-inch and sometimes 2½-inch waste-pipes. Sinks with round-hole gratings equal to about the area of an 1½-inch pipe are drained by a 2-inch and sometimes 3-inch waste-pipe. With such arrangements, how is it possible to keep such waste-pipes wholesome? And is it any wonder that complaints should often be made of the stink coming out of the air-pipes from such wastes?

The entrance-way into waste-pipes should be

Entrance-way into pipes.

as large (I prefer it larger) as the bore of the pipe, if good cleansing water flushes are to be sent through them.

Connections.

Before determining the sizes that such pipes should be, let us see what sized connections are generally used to such fittings.

With "tip-up" basins a good passage-way to the waste-pipe is provided in the "outlet" of the "receiver," and there is no difficulty in sending a fair flush of water through them to fill the bore of a 2-inch pipe, though I consider $1\frac{1}{2}$-inch pipe large enough for a single or a double "tip-up" lavatory, for the earthenware round-holed gratings (over the outlets of the receivers) interfere with the flush.

Plugs and Washers.

With "plug" basins, the average hole and countersinking are only equal to receiving an *inch* plug-and-washer, but the size chiefly used, I believe, is only $\frac{3}{4}$-inch; $\frac{1}{2}$-inch plugs-and-washers are also largely used. Let us examine the larger size for a minute. Fig. 101 shows an inch plug-and-washer. As you see, at A, the "lining" has reduced the way through it about $\frac{3}{16}$ths of an inch, leaving the water-way only $\frac{11}{16}$ths. How is it possible with such an arrangement to send a flush of water out of the basin which shall cleanse a 2-inch waste-pipe? The lining should be made the same bore as the "washer," as shown at B, Fig. 102, and the plug-and-washer should be increased in size to $1\frac{1}{4}$-inch at least; $1\frac{1}{4}$-inch waste-pipe with such an arrangement is large

enough to take the branch wastes from one or two lavatory basins. I prefer lavatories with $1\frac{1}{2}$-inch

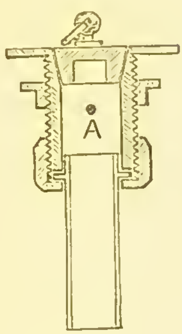


Fig. 101.

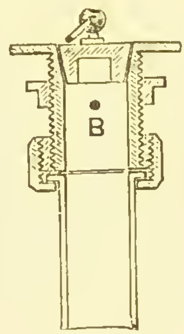


Fig. 102.

wastes, and waste-valves, having passage-ways through them equal to filling the bore of $1\frac{1}{2}$-inch pipes.

Waste-pipes from Baths.

BATH-WASTES.—As baths contain from thirty to fifty gallons of water—according to their size—the waste connections from them ought to be so arranged that every time a bath is emptied, a good flushing should not only be given to its waste-pipe but to the drain as well. The "outlet" of the bath itself should be equal to the area of a $2\frac{1}{2}$-inch pipe, and the pipe from it to its waste-valve, or stop-cock, should be trumpet-shaped—$2\frac{1}{2}$ inches at the bath connection and 2 inches at the valve connection—and then with a 2-inch "feather-waste-valve," 2-inch trap, and 2-inch waste-pipe, a bath containing fifty gallons of water can be emptied in less than two minutes, thus utilizing the waste water for cleansing out the bath-waste and flushing out

the drains. I consider a 2-inch pipe large enough to take the waste from two or three baths fixed on various floors as well as from several lavatory basins; but great care in such cases must be taken to ventilate each trap as explained in a preceding lecture, and if *round-pipe* traps, or syphon traps, are used, the air-pipe must be the same size as the traps upon the waste-pipe—*i.e.*, as the waste-pipe itself. (See Fig. 70, p. 175, showing a bath with its waste-pipe, &c., &c., fixed complete.)

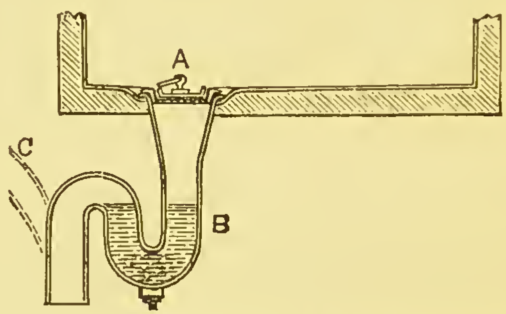


Fig. 103.—Section of an enlarged Waste-connection with Sink.

Sink Wastes.

Fig. 103 shows a 2-inch trap, with an enlarged mouth, connected to a lead sink, for receiving a 3-inch plug-and-washer, at A. By this arrangement a good passage-way is made to the waste-pipe. The sink can by this means be filled occasionally with hot water, and a good flush sent through the waste-pipe, for though the brass waste-connection is grated (to prevent stoppage of the pipe) it is of sufficient size to more than fill the bore of the waste-pipe from it. A $1\frac{1}{2}$-inch pipe is large enough for single sinks—"draw-

off" sinks—and a 2-inch pipe is large enough, with the arrangement just mentioned, to take the waste discharges from several sinks, fixed on various floors.

WASTE-PIPES FROM SLOP-SINKS.* — These pipes are often fixed too large to be kept wholesome. 4½-inch pipes, and sometimes 5-inch, are fixed, though the "outlets" of the slop-sinks fixed upon them may be only 2½ inches or 3 inches; the consequence is that such pipes after they have been in use a little while become extremely offensive. The air-pipes from them send out stink enough to contaminate the atmosphere over a large area near where they exist. If sanitary inspectors want to find out whether the sanitary arrangements of a house are perfect, let them put their noses over every air-pipe, from the waste-pipes, soil-pipes, and drains; and if such pipes, being ventilated at top and bottom, emit any great stink, the flushing arrangements are imperfect; for with self-cleansing traps, well regulated sized waste-pipes, soil-pipes, and drains, and good water flushing arrangements, no great stink ought ever to come from the air-pipes.

Slop Wastes.

For a single slop-sink in a private house a 2-inch waste-pipe is large enough; and for two or three slop-sinks, I consider that 2½-inch pipe is large enough, and 3-inch is equal to take the wastes from the slop-sinks of a five or six-storied

* See p. 233. Also see Figs. 53 and 70.

house, as well as from several "washing-up" sinks. In hotels, club-houses, &c., it is hardly safe to fix less than 3-inch pipes for such purposes.

All slop-sinks should have an efficient means for flushing * them out with water, for the contents of chamber utensils are often emptied into them undiluted, and where there is not a ready and efficient means at hand for washing out the sink and its waste-pipe, they soon get extremely offensive, and the larger the waste-pipe is the greater is the area for such offensive matter to corrode upon. When the outlet of such sinks is only 2½ or 3 inches, how is it possible to send a flush of water through them which shall fill the bore of a 5-inch or even 4-inch pipe to cleanse it? Therefore, if efficient flushes of water are to be made to pass through a waste-pipe, to prevent it from corroding and stopping up, and also to keep it wholesome, its size must be reduced in proportion to the *outlets* of the sanitary fittings fixed upon it—of course care must be taken to see that the pipe is not too small for its work.

Disconnection of Waste-pipes.

DISCONNECTION OF WASTE-PIPES FROM DRAINS AND THEIR VENTILATION.—All waste-pipes should have their discharging ends *open* to the atmosphere,† and to prevent splashings of

* A small automatic "Flush-tank" could be used in many instances.

† As long ago as 1872 I had lavatory-wastes disconnected from drains and their discharging ends left open to the atmosphere. In 1873, I had a lead "V-dip" trap made to receive the ends of sink-

filth upon the surface grating, and its surroundings, and also as a precaution against frost, to prevent droppings of water from the end of the pipe being frozen, such pipes should be made to enter the ventilating-shaft of the trap, a little below the ground level, as shown at K, Fig. 70. Where such traps would be exposed to *severe* frosts, the trap should be kept down into the ground, as shown at E, Fig. 104, and a brick air-shaft should be built over it, as shown at G, for the atmosphere to reach the discharging end of the waste-pipe, D, through the grating, F. (See traps for intercepting pipes from drains, pp. 178—181.)

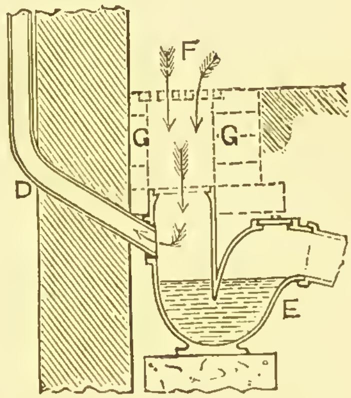


Fig. 104.
Section of a "Drain-interceptor," with brick air-shaft.

The upper end of all waste-pipes receiving dirty water should be exposed to the air for ventilation, as shown in Fig. 70, and as explained when speaking of soil-pipes—*i.e.*, the waste-pipe should be taken up full-size through the roof, or through the external wall of the house, and no

wastes and bath-wastes, above the water-line of the trap, for the atmosphere to pass into the pipes, and this trap was fixed, in the same year, in the ground outside the external walls of a house at Hornsey. The inlet or mouth of the trap was lengthened to reach the surface level of the ground, and a moveable grating was fixed over it.

such pipe should terminate within 8 or 10 feet of a window or opening into the house. Great care should be taken in determining the terminal points of such ventilating-pipes, and I recommend this to be always done on the spot where the whole of the surroundings can be duly considered.*

Trap ventilation.

TRAP VENTILATION.—As we have already seen, on a former occasion, *each* trap, fixed on one stack of waste-piping, requires ventilating. When there is only one trap and fitting branched into a waste-pipe, a vent-pipe can be taken off the trap at its "outgo," and branched into the waste, or air-pipe of the waste, about a foot or 18 inches above the level of the top of the trap. Where there are several traps branched into one waste-pipe, an air-pipe, the same size as the traps or branch wastes, should be taken out of the lowest trap and carried up to a foot or 18 inches above the highest, where it should be branched into the air-pipe of the main waste; and the branch air-pipes from the other traps should be branched into this ascending air-pipe of the traps, as illustrated in Fig. 70, p. 175.

I am quite sure you will agree with me that it is now time that we "ventilated" ourselves outside, and "branched" off homewards.

* See p. 269.

LECTURE VI.

HOUSE DRAINAGE AND VENTILATION.

Connections of Branches with Main-pipes. Connections of Pipes with Traps. Waste-pipes and Overflow-pipes from Traps to Water-closets, Baths, and Cisterns. Cistern-wastes and Overflow-pipes. Disconnection of Drains from Sewers and Cesspools. Drain Ventilation. Value of good Water-flushing. Water-supply to Sanitary Fittings. Grease-intercepting tanks. Pipe-freezing. Storage of Water: Slate Cisterns, Galvanised Iron Cisterns, Lead Cisterns. Action of Water upon Lead. How to line Wood Cisterns with Lead. Metropolitan Water Supply, Past and Present. Water-closet Rooms. Code of Rules for House Sanitation. Conclusion.

Details Perfect.

I AM afraid what I have to say to-night will appear fragmentary, and that some will think it too full of detail; but if ever we are to arrive at perfection in Sanitary Plumbing we must pay great attention to all its details. A general effect may do very well for a moving scenic painting, but a picture of life, as Frith's "Railway Station," which is to be handed down to posterity with the portraiture of an age upon it, and which is to immortalise the name of its artist, must have all its details perfect. And so a *general* sanitary arrangement may do very well for temporary encampments, but places which are to become our homes, and the homes of our children, must have every hole and corner lighted and ventilated; every water-closet, sink, bath, and lavatory con-

structed on sanitary principles; every trap self-cleansing; every waste-pipe, soil-pipe, and drain wholesome; in short, if there is to be no harbouring of filth in any part of the drainage system, it must be perfect in all its details.

Branch Connections.

CONNECTIONS OF BRANCHES WITH MAIN-PIPES.—I now come to that *branch* of my subject which refers to the connections of branch-pipes with main-pipes. All branches, whether for conveying dirty water, soil, or sewage, should be connected to their main-pipes so that the discharges through them shall pass into the main-pipe in the direction of its outfall, and so as not to foul any part of the pipe where it would not be cleansed by the flush of water following such discharges.

Range of W.C.'s. Bad Connections.

In fixing a range of water-closets on a floor, the branches from them are often made to enter the chief branch on its upper side, and in such a manner that the discharges through any of the minor branches nearest the main stack would foul the chief branch, where it would not get cleansed again until a water-closet more remote from the main stack were used—*i.e.*, a discharge from a water-closet through the minor branch, C, Fig. 105, would flow or splash up the chief branch towards B^1, where it would have no chance of being cleansed again until the water-closet branch E were used, which may not be for hours, perhaps days; at any rate the excrement so splashed back into the pipe

would often have time to dry and corrode upon it before a flush of water was sent into the pipe from the adjoining closet to cleanse such filth away.

All minor branches into a main branch having only a slight fall should enter at the side *obliquely*, as shown at K, Fig. 93, and never at right angles to or on the top of a main branch (fixed "horizontally"), as shown at C, D, E, Fig. 105. The junction should be kept well up from the bottom or bed of

Minor Branches.

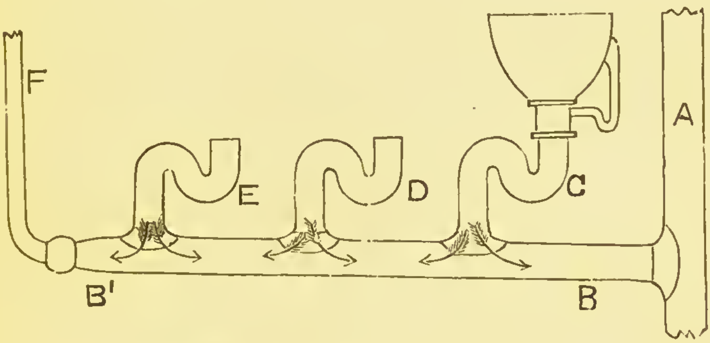


Fig. 105.—Diagrammatic Section of a Range of Water-closet Traps, to show Errors in the Branch Connections and Bad Ventilation.

the main branch-pipe, to prevent any matter flowing into the minor branches when travelling through the pipe.

It is also an evil to continue on the chief branch-pipe for ventilation in the manner shown at F in the Diagrammatic Section, Fig. 105; for the discharges from the minor branches, C, D, E, would often splash and flow up towards F, especially if more than one water-closet on the chief branch were discharged at one time, and as there would be no water traffic through this part of the piping, the

Main Branches.

matter thus deposited would not only become foul, but be liable, with added matter from time to time, to stop up the air-pipe, F, entirely, at any rate sufficient to prevent efficient ventilation.

Ventilating-pipes.

No ventilating-pipe should be taken from a waste-pipe, soil-pipe, or drain at a point which can be closed up by a stoppage or backflow in the pipe—*i.e.*, the ventilating-pipe should be connected to the waste-pipe, soil-pipe, or drain so as to make it difficult for discharges sent through such pipings to reach the mouth of the ventilating-pipe to choke it; and the connection should be so made that if anything splashed up into the air-pipe at any time, it should readily fall back or drain itself out again, as would be the case with pipes fixed as shown at T V, Fig. 93, p. 224.

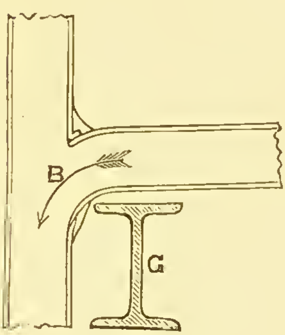


Fig. 106.
Branch "nosed" into Main-pipe.

Right Angles.

An iron girder, as shown at G, Fig. 106, or other obstacle, often prevents the plumber from giving a branch soil-pipe a proper fall, but he can generally manage to *nose* down the end of the pipe, as shown at B, Fig. 106, to prevent the discharges through the branch entering the main at right angles, and fouling it beyond its line of water thoroughfare.

Lavatory Ranges. Bad Arrangement.

How often one sees a range of lavatory basins fitted up with the branch wastes from them entering the *top* of the chief branch at *right angles*, as

shown in diagram Fig. 107. When a basin near the main waste, in such an arrangement, is emptied through a minor branch, B or C, into the main branch, E E', the contents of the basin would flow both* ways—*i.e.*, a discharge of soapy water through branches B and C would flow up the main waste towards E', and its suds would hang about the pipe and corrode upon it, unless basin C or a basin still more remote, were immediately used.

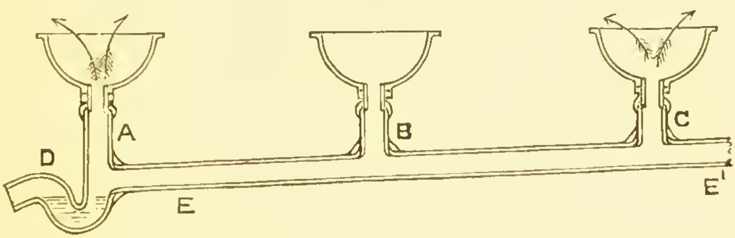


Fig. 107.—Diagrammatic Section of a Range of Lavatory Basins, to show Errors in the Branch Connections.

There is another evil attending such an arrangement. A discharge of water through branch C would drive the vitiated air in the main branch, E, out through the basin, A, into the room, as shown by the arrows; in fact, there would be a constant circulation of air from basin to basin, and that air, passing through a pipe which would often be charged with bad air, from stale soapsuds and

* An ocular demonstration was given with a small washhand-basin and a *glass* waste-pipe, showing this. A little soapy water was put into the basin (similar to the basin, B), and on pulling out the plug the water flowed both ways in the pipe, and though the water drained itself out of the piping, the *suds* remained in the pipe.

other matter adhering to the sides of the pipe would be breathed by the persons bending over such basins to wash their hands; for in the "tip-up" basins the impure air would easily come up between the basin and the "receiver," and in plug-basins (though the plug may be in its place) the air would easily escape through the overflow-arm.

Range of Basins into one Trap.

Another error is often made in the arrangement of lavatory wastes, where a range of basins is discharged into *one* trap. The main branch is taken

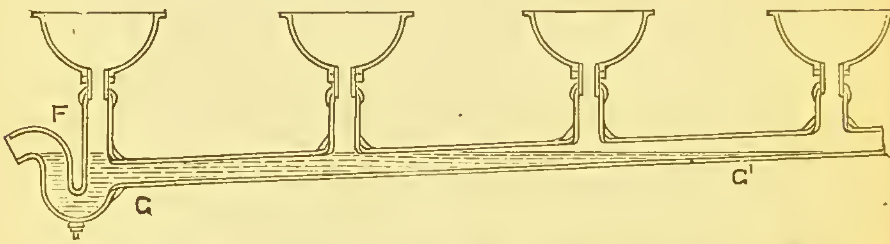


Fig. 108.—Diagrammatic Section of a Range of Basins, to show the Evil of Emptying into one Trap.

into the heel of the trap in such a way that about two-thirds of its length always stand full of water, as shown in the diagrammatic section Fig. 108. When this is the case, how is it possible to change the water standing in the waste-pipe, G G', and trap, F, with a flush of water sent through either of the basins? The body of water standing in the trap and piping might become very offensive from the use of scented soap and the washings-down of the lavatory top, and it would prevent the waste-pipe from being

cleansed; for no flush of water could be sent through the pipe with any cleansing force in such an arrangement.

When a waste-pipe from *one* "fitting" is branched into the trap fixed under *another* fit-

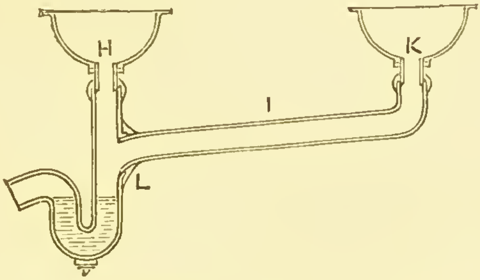


Fig. 109.—Error in Branch Connection.

ting, the connection should be so made that no air can travel from one to the other, as it easily could in the arrangement shown in diagram, Fig. 109—*i.e.*, the air would be circulating constantly from H to K, through the foul waste-pipe, I, or *vice versâ*.

Connections with Traps, Evils of.

If one trap must be made to receive the waste-pipes from more than one basin, sink, bath, or urinal, when fixed adjoining each other, the ends of such pipes should be taken into the trap under the normal level of the standing-water, as shown in diagram Fig. 110, at L; but I do not like even this arrangement. It may do for

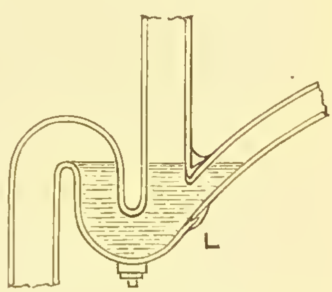


Fig. 110.—A Better Mode of Connection than Fig. 109.

certain places, but is not perfect in principle, and therefore should never be carried out in fixing sanitary fittings near a living-room or bedroom. In dressing-rooms it is common to find the lavatory-waste connected with the bath-waste, either as shown in Fig. 109 or Fig. 111; but as it is impossible to keep such arrangements absolutely sweet, we will just look at the evils attending them.

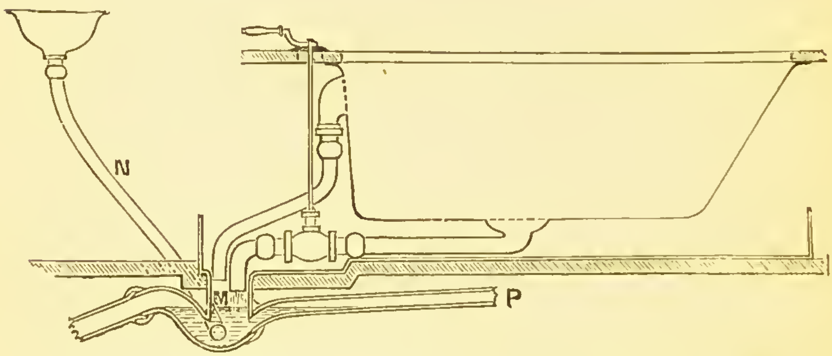


Fig. 111.—Section showing Evils of Emptying several Fittings into one Trap.

One Trap and several Wastes, Evils of.

When two or more waste-pipes discharge into one trap, with their ends under the water-line, the filth carried down one pipe *floats* up into one or more of the other pipes, and collects and lodges there. This will readily be seen by looking at the illustration Fig. 111, showing such an arrangement. A discharge of soapy water is sent out of the basin-waste, N, and the suds from it immediately float up into the dip-pipe of the trap, M; and though the matter sent up may only be small in one usage, it becomes large from many usages.

The lavatory would most likely be in constant use, but the bath may not be used more than two or three times a week, and when used the discharges from it would not wash out the dried filth, for that would have collected upon the sides of the dip-pipe, M, and on the outer side of the bath-waste, above its discharging orifice. Besides, in such arrangements, a *large* trap is often used with only small branch-wastes into it from the adjoining "fittings," so that the *trap* could not get properly cleaned out by a flush of water sent into it through such pipes. The fact is that in such cases filth collects very quickly in the dip, or inlet part of the trap, M, and on the outer side of the discharging end of the bath-waste, standing in the mouth of the large trap.

Each Fitting its own Trap.

When each fitting has its own trap, the water-flushes through it can be made to cleanse every part of it, provided that the water-way from the fitting into the trap is of the same bore, and that the trap is of a self-cleansing form, and only of such a size * as can be readily flushed out. (See perfect arrangement, Fig. 70, p. 175.)

"W.C." Wastes connected to "Safe" Traps.

WASTE-PIPES AND OVERFLOW-PIPES FROM SAFES TO WATER-CLOSETS.—It is still the practice with many country plumbers, where they fix safes under water-closets, to connect the waste-

* The traps used for such purposes are generally much too large: 4-inch syphon-traps, or 6-inch (and even 8-inch) D-traps—that is to say, little *cesspools.*

pipe of the safe with the W.C. trap, and to fix the pipe of too small a size to be of any value in any great overflow of the water-closet. But, supposing the pipe to be large enough to take away any overflow from the closet or leaky supply-valve, its connection with the trap of the water-closet, where the stoppage which has caused the overflow has occurred, would prevent the water getting away, and the safe would be of no good in preventing the water from overflowing and doing damage. But the chief evil in such an arrangement is that excremental matter would flow up into this waste-pipe (and perhaps into the safe) from time to time, and foul the pipe where it would have no chance of being cleaned again ; and every usage of the closet would cause a disturbance of the water standing in this pipe, and make it smell. The evil is much aggravated when the pipe is connected to the cheek or heel of the water-closet trap with its orifice partly above the level of the standing-water ; for soil-pipe air would then readily escape through the waste-pipe of the safe into the house. Such arrangements exist in scores of houses to-day.

Separate Traps.

The system of fixing a *separate* trap under the safe, and taking the waste-pipe from it into the soil-pipe, is radically wrong, though, with a "weeping"-pipe to charge it, it is an improvement on the method last mentioned. But in a stack of water-closets such traps often get unsyphoned, and then they become inlets for bad air to the house, and

may continue for hours and even days unsealed, and all the time the air from the soil-pipe would be escaping into the house; for the water-closet with which they were connected may not be used for days together to re-charge them with water—*i.e.*, to re-seal the traps.

The only *safe* way of fixing "safe-wastes" is to connect a 2-inch (or $1\frac{1}{2}$-inch) lead pipe to the safe, and carry it through the external wall, as shown in Fig. 112, leaving its end open for ventilation, Open Wastes to W.C. Safes.

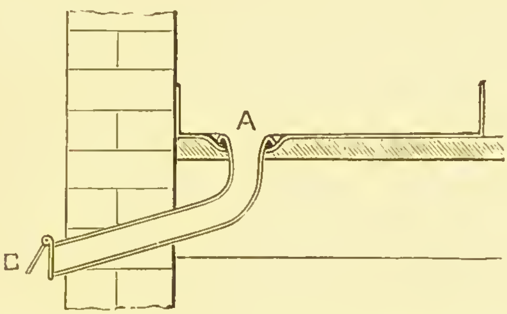


Fig. 112.—Section of W.C. Safe and Overflow-pipe.

except where birds are likely to build in it, or the frosty air can blow through it to freeze the service-pipe to the water-closet, or the water-closet itself. There is very little fear of this when the ends of such pipes face the south, and the service-pipes are protected; but where the ends of overflow-pipes are open to the north, or north-east, the air whistles up the pipe and freezes the basin-water—perhaps breaking the basin and bursting the pipe. It is, therefore, better to solder a brass or copper-hinged flap on the ends of such pipes, to shut out the frost

and to prevent birds building in them, as shown at B, Fig. 112. When, however, such pipes can be left open, they help to change the air in the W.C. room, with a few perforations in the riser of the W.C. seat. Of course where this is done the space between the top of the basin and the seat must be packed with india-rubber, to prevent any draught coming to the occupant; and when there is any frost, a *floating plug*,* made of wood, as shown at B, Fig. 113, could be put into the mouth of the overflow-pipe to shut out the draught; but this wants personal attention, for servants never think of such things.

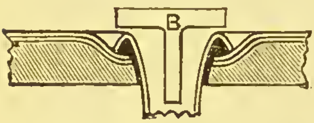


Fig. 113.—Section showing "Floating Plug" over mouth of Overflow-pipe.

The mouth of the overflow-pipe should be enlarged, as shown at A, Fig. 112, and soldered to the safe, and the "outlet" end should be kept at least a foot below the safe, as shown at B, for the weight of the overflowing water to well open the flap, where it exists.

Safes under Cisterns.

OVERFLOW-PIPES TO SAFES UNDER CISTERNS—SLATE OR GALVANISED IRON—AND BATHS should be treated in the same way as overflow-pipes to water-closet safes—*i.e.*, a pipe of sufficient size to take off the supply of water to such "fittings" should be fixed to the safe, and carried through

* This arrangement was used in my house during the last severe winter, 1880—1881.

the external wall, to discharge with an open end outside; and to prevent such pipes becoming inlets for bad air, the ends should be kept well away from all ventilating-pipes to waste-pipes, soil-pipes, and drains, and from places where any bad air could reach them.

Safes under Baths.

Where stop-cocks are used for supplying a bath with water, or where any supply-valve by leaking drops its water into a safe, provision should be made in the connection of the bath-waste with the safe for taking off such leakage; for if this were allowed to run down the overflow-pipe in frosty weather, the word "safe" would be a misnomer, for the dropping-water would freeze up the outlet of the overflow-pipe, and then if an overflow took place, it would soon flow over the safe on to the ceiling, giving it a bath, and the people under it a shower bath.

Cistern-wastes Separate.

WASTE-PIPES FROM CISTERNS should never be connected with any other kind of pipe. As just explained for overflow-pipes from cistern safes, waste or overflow-pipes from cisterns should discharge in the *open air, well away from all places where any impure air can reach them*; for when they discharge over a gully, or other drain-trap, they act as *air-pipes* from such traps—that is, any drain-air escaping through the trap (caused by the water in such traps having evaporated, or by the disturbing action of discharges into the trap) would pass through the waste or overflow-pipe to the

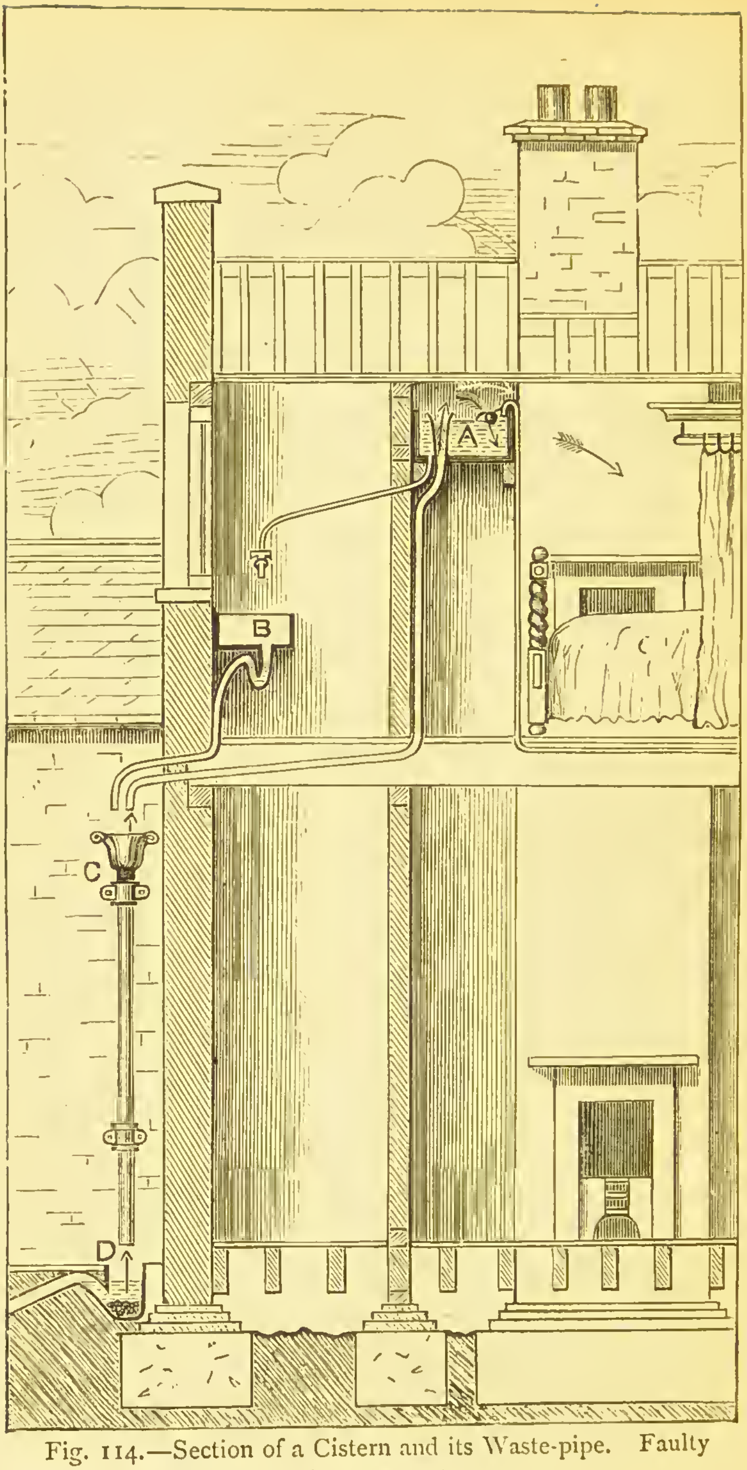


Fig. 114.—Section of a Cistern and its Waste-pipe. Faulty Arrangement.

water in the cistern and contaminate it.* It is also a great evil to discharge such pipes into a rain-water-pipe with which may also be connected a sink or lavatory waste; for such rain-water-pipe and waste-pipe combined is sure in time to become foul, and the bad air arising from it would readily escape through the cistern-waste to the water in the cistern. It is all very well to blame water companies for not supplying pure water, but when no great trouble is taken for keeping the water pure—should it ever come into the cisterns pure—we cannot very well be angry, nor can we dip the directors of water companies in water without risk of being ourselves dipped in it. The other day I was called in to examine the sanitary arrangement of a house which had recently been overhauled and reconstructed. I found about four-fifths of the work well done, but among one or two things imperfectly done was a cistern-waste. The pipe had been disconnected from the water-closet-trap and continued and made to discharge over a rain-water head (as illustrated in Fig. 114).

Evils in fixing Cistern-wastes.

* It is a monstrous thing that any man, after disconnecting a cistern-waste from a water-closet-trap, could connect that waste with a *drain-trap!* Yet this is often done. Cistern-wastes are made to discharge under the grating of a gully-trap, Mansergh-trap, or some other trap connected directly with the drain; and if they are not made to discharge *into* such traps, they are made to discharge *over* them, where any air emitted from the traps could pass through them to the water in the cistern. And these traps are liable to send out a large amount of bad air, for they are generally so large that they hold a good amount of water and filth, and though "only" lavatory wastes may discharge into them, the decomposing soap makes them very offensive.

The cistern itself was on the attic floor, and placed in a corner of the servant's *bedroom*. I am not now considering the position of cisterns, so I say nothing about that, except that the water stored in such a quarter must get contaminated.

Cistern-wastes as Air-pipes.

The waste-pipe acted also as an overflow-pipe, and being thus open at both ends, there was nothing to prevent the bad air, from the several lengths of rain-water-pipe and sink-waste combined, over which the cistern-waste discharged (as shown at A and C), passing to the water in the cistern. This combined sink-waste and rain-water-pipe emptied itself into a *large* gully-trap, as shown at D, in the back area of the house, and as such traps are non-cleansing—as we saw in a previous lecture—this trap was in a very foul state. Every time the water in it was disturbed, a bad smell was emitted from it, and this partly escaped through the window just over the trap into the house, and found its way up the several lengths of the foul waste-piping, and thence through the cistern-waste, A, to contaminate the water in the cistern and the air in the servant's bed-room. A branch-waste from a sink on the third floor was taken into this combined sink-waste and rain-water-pipe, as shown at B; but this branch waste was *trapped*, proving that the plumber or director of the work had an idea of such piping becoming foul; but the mystery is why he carried such a pipe as a cistern-waste into it. If you want to find out how far the air coming out of a drain-trap will travel, fix

half-a-dozen lengths of rain-water-pipe over the trap, and carry a long length of cistern-waste into the head, fixed on the top of this rain-water-pipe, and then go into the house and light one or two fires near the cistern; then if you will put your nose over the mouth of the trumpet-waste while some one throws some essence of peppermint down the drain-trap, you will soon smell the peppermint — *i.e.*, some essence of peppermint thrown down into the gully D, Fig. 114, would be smelt by any one standing in the bedroom near the cistern-waste, A. Therefore cistern-wastes should discharge themselves with *open ends, well away from all drain-traps, and ventilating-pipe terminals.* When they cannot be made to discharge into a roof-gutter, or on to a flat or yard, and the only place that can be found is a rain-water head, treat the standing-pipe in the cistern as a *plug*, by soldering over its top or mouth, and fix an *overflow-pipe* to the cistern, as described to the cistern safe, taking care that such pipe is of sufficient size to take off the full supply of water to the cistern (in case of failure of the ball-valve); and if you err in this matter, err on the side of largeness.

Cistern-wastes. Places of Discharge.

Before we speak of water-flushings in pipes, we had better see that the drain is properly connected with the sewer, or we shall run some risk of being flooded.

Drain-Disconnection.

Disconnection of Drains from Sewers and Cesspools and Drain-ventilation.—No drain is properly connected with the sewer (or cesspool, as the case may be) which would allow the sewer or cesspool air to get into the drain unless very largely mixed with the atmosphere.

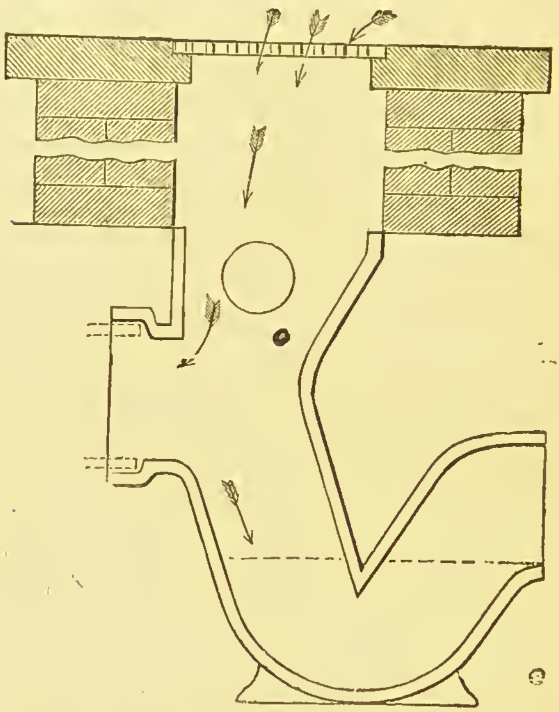


Fig. 115.—"Sewer-interceptor," with open Air-shaft.

Every drain should be trapped off from the sewer by an efficient and self-cleansing trap, and this trap should be fixed in every case outside the house. If circumstances will admit of it, an air-shaft should be built over the trap, as shown in Fig. 115, for the admission of fresh air into the

house drain; or a large man-hole and air-shaft might be built up from the bed of the drain, close to the trap, as shown in the illustration Fig. 116, for the upper side of the drain at such point to be well open to the air, as shown at A and B. An inspection pipe to the sewer side of the drain can

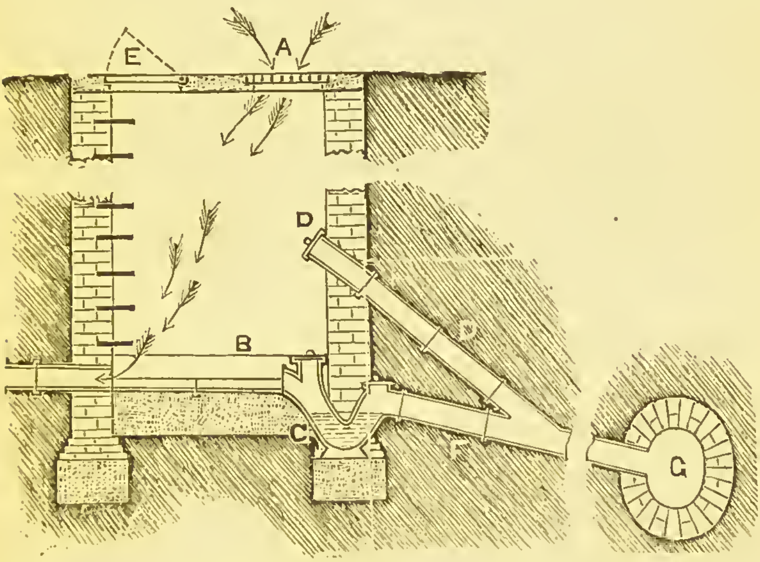


Fig. 116.—Air-shaft and Man-hole. Access to Drain and "Sewer-interceptor."

be formed as shown at D, D[1], with a stopper over the end at D.

Where the drainage of the house has been carried out on the principles laid down in these lectures, there is no risk in opening a well-flushed and well-ventilated drain to the air, as shown in Fig. 115, or at A B, Fig. 116, provided the trap, C, used for such purposes is a *self-cleansing* one, having a good water-seal (to allow for evaporation),

and provided that it is only of such a size as to admit of the whole of its standing-water being changed by a flush of water sent through the drain. But to fix such an arrangement—*e.g.*, in the area of a London house—and to connect it to an old brick drain, saturated with sewage matter, and of such a size that no amount of water that could be sent into it would flush it; or to fix it even to a pipe-drain too large to be flushed out, and therefore too large to be kept wholesome, is to run great risk of getting intolerable stinks at such openings; and if needing to pass near them, I should want a neck as long as a giraffe's, or a body as tall as Chang's, to keep my nose well up out of the way of such offences to mind and body.

Open Drains. Experience wanted.

It requires experience in such matters to treat open drains successfully; but to fix a 9-in.* trap where a 6-in. would be ample, or to fix a 6-in. where a 4-in. would suffice, is to run a risk of getting bad smells into the house, if the latter is near such openings, for the contents of the trap would under such circumstances only rarely be entirely changed. Where the outlet end of the drain into such traps as we are now considering could not be left open to the atmosphere—as shown in Fig. 115, or at A B, Fig. 116—for various reasons, as, for instance, being an old drain which could not be properly flushed out (and might not be changed, on account of the expense), or because

* There is hardly a mansion in London which requires so large a trap (9-in.) to take away its sewage.

the opening would come directly under or near a window, or close to an opening into the house, or under a covered-way where any bad air emitted from the trap or drain would get pent up, to enter the house directly a window or door near the place was opened. In such cases, the opening over the

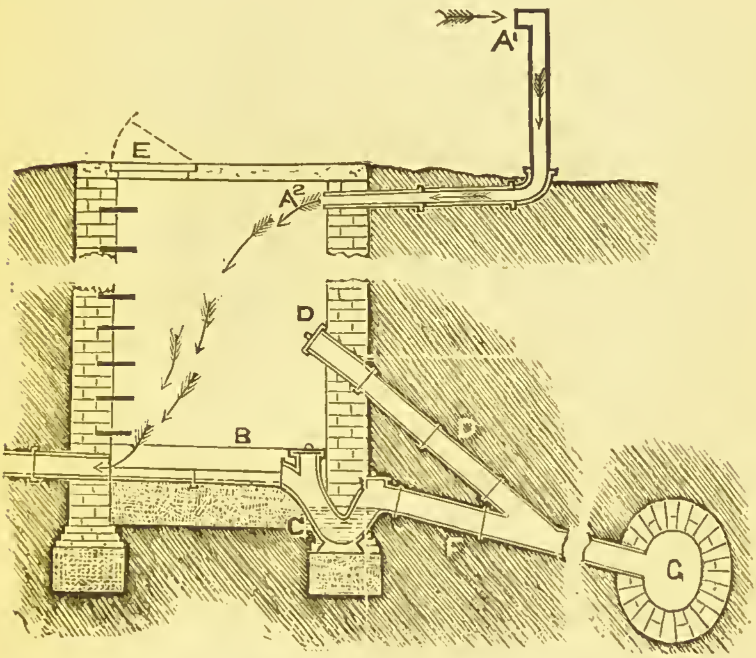


Fig. 117.—Air-induct, through Man-hole, to Drain, &c.

top of the air-shaft, or trap, should be sealed up, as shown at E, Fig. 117, and an *air-induct*-pipe taken into it, as shown at A^1 A^2, Fig. 117, for the admission of fresh air into the drain from a point well removed from the house. Where the end of such induct-pipe could not be kept some little distance away from windows, doors, or passenger traffic, a mica-valve should be fixed over its mouth

Air-inducts.

to prevent, as much as possible, any drain-air escaping through it.

Pipe-shaft and Air-induct.

Where the expense of building a *brick* air-shaft or man-hole, as shown in Figs. 116 and 117, is greater than could be afforded, a *pipe-shaft*, as shown at C, Fig. 118, could be formed with a small

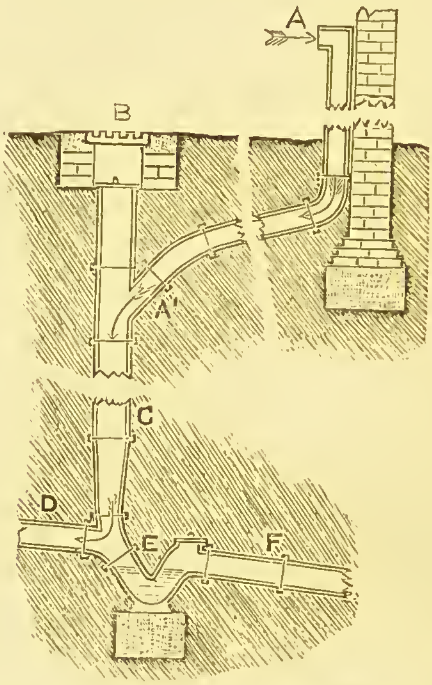


Fig. 118.—Pipe-shaft, with Air-induct to Drain.

cost; and if the top of the shaft could not be left open to the air, for reasons just explained, when speaking of the *open* air-shaft, the top of this trap inspection-shaft could be sealed over as shown at B, and an air-induct-pipe taken into it, as shown at A A[1], Fig. 118, with a mica-valve over its mouth, or not, as circumstances required. I

have had many such pipe-shafts put in, and found them to answer admirably. A *plunger*, attached to a long rod, can easily be pushed down into the trap, E, for unstopping it, should it ever get stopped up—a thing never likely to occur where the drainage has been properly carried out, and is periodically flushed.

Induct pipe to roof.

Where it is not possible to make an air opening directly over the drain, as shown in Figs. 115 and 116, or to fix an induct-pipe, as shown in Figs. 117 and 118, the induct-pipe could be continued up to the roof, but its mouth would have to be kept well away from all windows, for lengthening the pipe in such a way would cause it to act at times as a flue or upcast-pipe. In other words, it would become the ventilating-pipe of the drain, especially if the wind had free access over the top of it, by removing the atmospheric pressure, and also during the time large discharges were passing through the drain. The *up-cast* pipe of a drain should be carried up as high as possible above the level of the top of the induct-pipe, if good results would be obtained—*i.e.*, causing good air currents through the drain.

Plumber's Knowledge of Drainage.

DRAIN-VENTILATION.—Though the plumber may have nothing to do with *fixing* sewer-traps and drain-traps such as we have just been considering, he has generally to do with the *ventilating-pipes* of the drain, for in most cases he is called upon to fix them, especially when of lead; and as

no drain is properly ventilated unless the air in it is changed, and as this cannot be done without an inlet as well as an outlet, the plumber's knowledge of drainage matters ought to extend as far as the sewer. I don't mean that he should be required to *plan* the drainage of a house, but his knowledge of sanitary matters should be such as to lead him to carry out every part of his work in an intelligent manner. If sewer-air is allowed to pass freely into the drain, the whole atmosphere surrounding the upper portion of the house —where the plumber has terminated the ventilating-pipes of the drain—would become contaminated, and such vitiated air would often get sucked into the house. If such smells were sufficiently pronounced to call special attention to them, they may get set down to imperfect plumbing. At any rate, there would not be great wisdom in making the plumbing sanitarily perfect, and leaving the drains imperfect; for if one is to be made ill by breathing polluted air, it may as well come from defective plumbing as defective drainage.

House Drainage and Ventilation.

I suppose at the present time the larger proportion of the house drains of the United Kingdom are unventilated, and the other portion but imperfectly ventilated. I have here a scheme of drainage laid down, chiefly with glass tubes, as in one or two experiments which I am now about to make with some smoke I want you to see that with *one* ventilating-pipe from a drain, though as large as the drain itself, and no matter where it

may be placed, there is *no* ventilation of the drain—*i.e.*, the air in the drain is not changed unless *two* (or more) openings are made in it—an inlet and an outlet—for a current of air to pass in at one end and out at the other.

Plan of Glass Model.

Fig. 119 shows a plan of the glass model used. The lines showing the drainage and "fittings" are

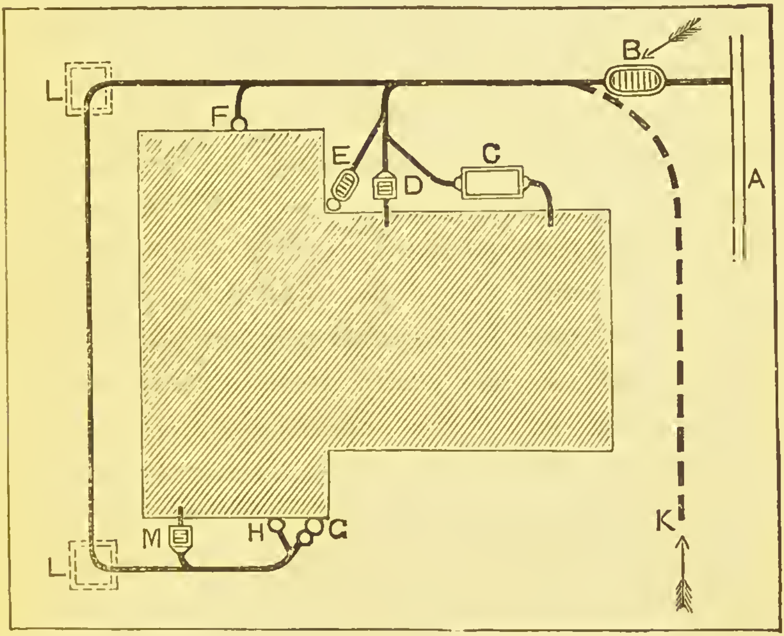


Fig. 119.

exaggerated. A, represents a sewer; B, a "sewer-interceptor" and fresh air inlet to house-drain; C, "grease-intercepting tank," from scullery sink; D, a "drain-interceptor," taking waste-pipes from sinks, lavatories, &c.; E, "soil-pipe disconnector;" F, upcast ventilating-shaft; G, "soil-pipe trap" with mica-valve, for "foot-ventilation;" H, upcast

pipe at head of drain; K, a point more remote from windows or doors than B—where the opening B would be too near the house or passenger traffic; L, man-holes giving access to drain; M, drain-interceptor taking waste-pipes from baths, &c.

As this glass model was fitted up chiefly to show how to *aerate* a drain, no "syphon" is shown for *flushing* it. A flushing-tank fixed so as to discharge itself into the drain, near its head, at G, would perfect the system. See p. 276.

The "drain" was filled with smoke, but with the ventilating-pipe, H, open, and the discharging end of the drain, B, sealed over (the induct, K, being sealed over as well), no smoke would come out of the ventilating-pipe. The drain was then opened at K, and the ventilation immediately commenced—that is, the whole of the smoke in the tubing came out of the ventilating-pipe, H. The ventilation could be stopped at pleasure, and this was done several times by sealing either the inlet, K, or the outlet, H; for directly the one or the other was sealed, the ventilation ceased—that is, the smoke ceased to pass out of the tubing with one pipe closed.

With another ventilating-pipe fixed in the middle part of the drain at F, and both ventilating-pipes, F and H, left open, and the inlets, B and K, sealed over, smoke could readily be cleared out of the upper part of the drain between the two ventilating-pipes, but the *smoke remained stagnant in the lower part of the drain*, between B

and F, and this could only be got out of the tubing by giving it air at B or K.

The ventilating-pipe at the head of the drain, H, was then made the upcast, by sealing over the ventilating-pipe, F, in the middle of the drain, and a smoking-paper was held at K, over the mouth of a glass tubing, fixed as shown by the dotted line. The smoke could be seen passing (rapidly at times) through the glass tubing, and out of the upcast pipe, H. And this is what takes place in practice, as I have proved over and over again.

I have also proved with this same model that it makes only a slight difference when an *induct-pipe* is used, as shown in Fig. 118.

Localising Drains.

In this drainage arrangement, I have disconnected each stack of soil and waste-pipe, thereby localising them; and that each pipe, as well as the drain, may be perfectly ventilated, I have given each its own inlet and outlet; in fact, I have treated them here as they ought to be treated in practice to secure perfect ventilation throughout the whole system.

Ventilating-pipes.

It only remains to say a word or two on the ventilating-pipes themselves, before passing on to consider the value of good water-flushings in drains. In fixing ventilating-pipes for upcasts to drains, take care to keep them well above and well out of the way of all openings into the house, as explained under the head of soil-pipe ventilation in the previous lecture, so that the bad air coming out of such pipes may not get into the house

Venti-lating-pipe Terminals.

through a chimney, skylight, dormer-window, or any other opening. It would really be amusing, were it not for the serious consequences likely to arise, to take note as one travels about of the ill-considered positions in which such pipes were

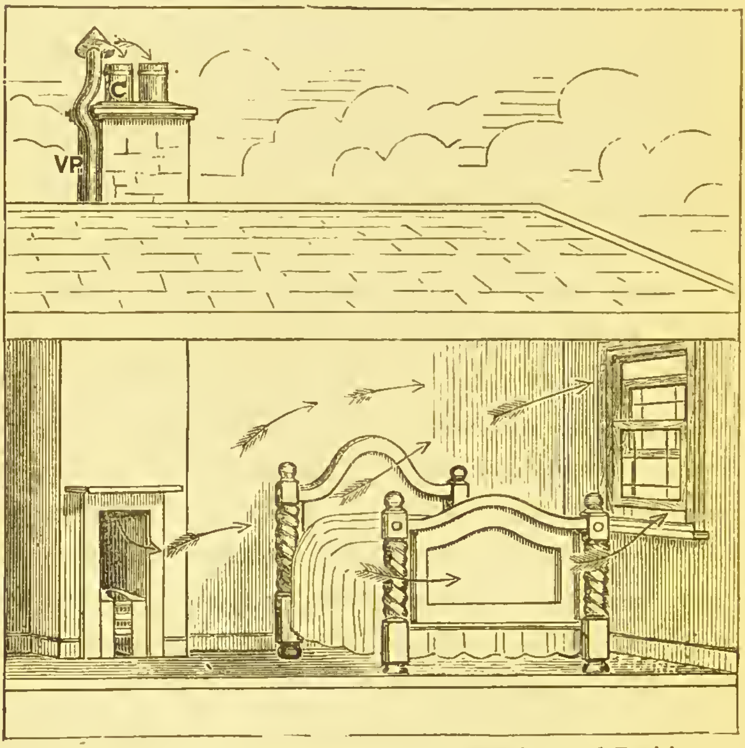


Fig. 120.—Drain Ventilating-pipe Terminal. Bad Position.

terminated. Sometimes they are placed where no wind can reach them at all; at other times they are left so that the smallest wind may blow the air emitted from them right into a window; and in other places, by crossing and re-crossing the roof, they are carried up some tall chimney-stack and terminated at a point so situated that

the slightest downward pressure of the atmosphere presses the bad air from such pipes down the chimney into sleeping* or other compartments. Fig. 120 shows a ventilating-pipe terminated as described, and this pipe terminal can be seen by any one walking down a street on the south side of the British Museum, for the *ventilating-pipe* (the pipe only,) illustrated in Fig. 120 was taken from it.

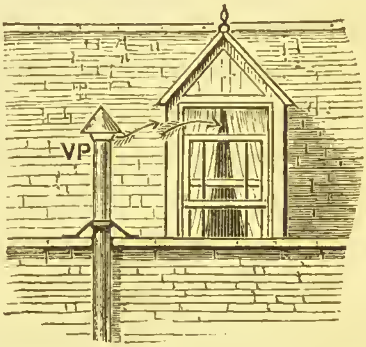


Fig. 121.—Soil-pipe Terminal. Bad Position.

Fig. 121 represents a ventilating-pipe terminating close to a dormer-window, with the arrows pointing out the evil of such an arrangement. Scores of such pipes may be seen almost anywhere, where the soil-pipes and drains are ventilated at all. I counted a large number at a sea-side place where I was staying only a short time ago, and yet in the same town the Sanitary

* Since delivering these lectures, I have been staying at the Royal Castle Hotel, Lynton, which is built on the crest of a hill overlooking the Bristol Channel, and the valley of the East Lynn. Being anxious to get a good view from my bedroom window, I selected a bedroom at the top of the house, and lived to regret it; for though the morning's sun "tipped the hills with gold," I could not see them for the dense smoke which filled my room. I was not long in seeing where the smoke came from, so I jumped out of bed and provided an exit for it by opening one of the windows, and then returned to bed again to watch the movements of the smoke. Down the chimney it came in clouds, filling the room from floor to ceiling, and went out of the window in a fitful sort of way, and as

Inspector had a brass plate on his gate as large as a small sign-board. Perhaps this obstructed his vision.

Venti-lating-pipes fixed Outside.

No ventilating-pipe from a drain should be fixed inside a house if it is at all practicable to fix it outside. To prevent the possibility of drain-air escaping into a house from a ventilating-pipe through a leaky joint, broken pipe, nail hole, or any other defect, such pipes should be fixed *outside* the house. When such pipes are of lead, and are wanted to stand for a century or centuries as lead rain-water pipes would, they should be kept out of the power of the sun as much as possible, for with soldered joints the pipe would have no freedom for expansion or contraction, as in lead rain-water pipes with slip socket joints, as explained in our last lecture.

Water-flushing.

VALUE OF GOOD WATER-FLUSHING.—If water-carriage is to be the system of removal, water must be used freely. If the slops and sulliage of a house are to be effectually removed, whatever else may be limited in a house, water must not be. Make a canal the roadway for your boats of commerce, and then limit its water supply, and where will the boats be? Why, stranded, of course.

it gave every sign of continuing this course for some hours, I jumped out of bed and got out of the room as quickly as possible, feeling glad that it was only *smoke*, for if a ventilating-pipe had been near the top of this chimney it might have been *drain-air*, instead of smoke, and what a change of air that would have been, even though I had come from Cologne. The arrows in Fig. 120 show the danger of terminating ventilating-pipes near a chimney.

Make water the cleansing-power of your waste-pipes, soil-pipes, and drains, and then limit its use, and where will the filth be? Why, lodging, decomposing, and corroding in the pipes. Or make water the drainage *scavenger*, and then limit its supply, or cleansing force, and how is the drainage to be swept out and cleaned? How we should ridicule a Vestry Board which sent a street scavenger to clean Regent Street, say, with one sweep of his broom—to begin at one end and push it right through the centre of the street to the other end; and yet such a swept track as that represents the treatment a soil-pipe often gets. The pipe is befouled all over by an offensive excremental discharge sent into it; but the water used for washing out the pipe is only sufficient, in many cases, to cleanse a channel down its sides.

Look at this matter a little more closely. A pailful of slops from chamber utensils is thrown down a water-closet in a body sufficiently large to foul the whole of the soil-pipe belonging to the closet, and, at the same time, a water-waste preventing-valve (fixed under the seat) is opened for two gallons of water to pass into the closet to cleanse it; but this water, squirting into the water-closet as if it came from a boy's syringe, is of little value for cleansing the pipe, as it does not cover the whole of the parts fouled, and the parts unwashed become coated over with excremetal matter, corroding up the pipe and making it unwholesome. The real cause of obstruction in Slops.

pipes is the want of good water-flushing. It would be possible to stop up a 6-inch pipe to a water-closet or urinal with a poor supply of water to it quicker than a 3½-inch one with a good supply of water.

Adequate Water-flushes.

No waste-pipe, soil-pipe, or drain can be kept wholesome unless adequate flushes of water are sent through them immediately after discharging dirty water or excremental matter into them; and before such discharges are sent through the traps and such pipings, they ought to be largely diluted with water, especially in such cases as the contents from chamber utensils. Measure water into slop-sinks and water-closets, &c., by the tablespoonful, and whatever else may be wholesome about the house, such fittings, with their belongings, will not be. I know that it is possible to utilise two gallons of water—the quantity allowed for water-closets by the London water companies, in accordance with the Metropolis Water Act of 1871—in such a way that it shall pass into a closet with greater cleansing power than twice that quantity badly supplied; but that is not the present question.

Two-gallon Supply.

Two gallons of water are insufficient for keeping a water-closet and its belongings wholesome; and speaking to a body of practical men, their opinion in the matter I shall be glad to hear. Are there ten men in this room who consider a two-gallon water-flush sufficient to cleanse a water-closet, basin, trap, soil-pipe, and drain after usage?*

* A hearty "No!" came from all parts of the room at each delivery of the lecture.

We must knock at the door of Parliament, and send in a message stating that a large body of practical plumbers find from experience that two gallons of water are insufficient to keep a "house of commons" wholesome, and that if more water cannot be allowed, such places must be abolished.

Bad Appliances.

But when plenty of water is to be had, if not for the asking, yet by the pulling of a handle, the flush is often interfered with by bad appliances. The supply-valves, instead of being equal to flushing out a 4-inch or 4 -inch soil-pipe, are often only of sufficient size to cleanse a 1¼-inch or 1½-inch pipe; or perhaps the boiler-screw or cistern connection, A, is of smaller diameter than the service-pipe, as shown in the woodcut, and the water is wire-drawn through it—if I may use such an expression—or the bends in the pipe may be *contracted*, as shown at B and C, Fig. 122. When either of these evils occurs, how can the water pass into a water-closet or "fitting" with a good cleansing force, supposing the service-pipe to be only of a size sufficient for that purpose.*

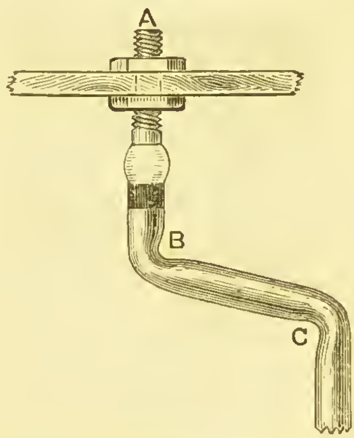


Fig. 122.—Service-pipe contracted at the bends.

* A valve-closet with a "V-dip" trap and a short length of 3½-inch lead soil-pipe and about a 2-foot length of *glass* soil-pipe, was fitted on a stand, and several experiments were made to show

Field's Annular Syphon.

Having already explained how *small* connections to bath-wastes, sinks, and lavatories interfere with the flushes of water from them for cleansing their waste-pipes, I will not occupy your time further on this matter, except to call your attention to Mr. Roger Field's "Syphon Flushing-Tank,"—Fig. 123. This apparatus may be made a valuable means for flushing out the drains of a house automatically, as well as for other purposes. When the rain-water of a house, in town or country, is not used for any purpose, and where the soil-drain is used for taking it away, a good sized "flushing tank" should be fixed near the head of the soil-drain, and the rain-water collected into it so as to pass into the drain in large volumes for cleansing its whole length, instead of dribbling into it in many places, and being of little or no value for flushing out the drain. There

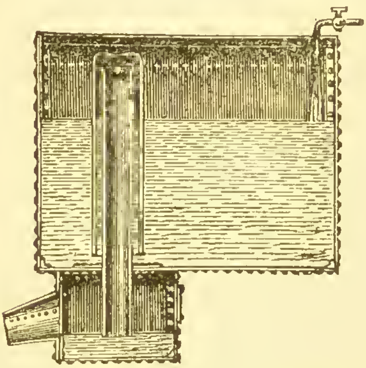


Fig. 123.—Section of "Syphon Flushing-tank."

by ocular demonstration that soil-pipes are readily cleansed when good water-flushes are sent through them, provided that the soil-pipes are not too large. The piece of glass soil-pipe (which was fixed at the bottom of the lead soil-pipe), was well coated over on its inner side with plumbers' "soil," and though this was partly dried on the tubing, by warming it with the flame from a piece of burning paper, a full and quick discharge of water from the water-closet washed off all the "soil." This experiment was repeated several times with a like result.

is this additional advantage in such an arrangement—namely, there would then be only *one* opening into the soil-drain for the rain-water instead of many. The tank for this purpose can be made in brick and cement, or of galvanised iron of any size, and the syphon adapted accordingly. An auxiliary supply of water can be laid on to the tank, for working it at certain intervals—every five, ten, fifteen, or twenty-four hours, or at pleasure. This arrangement can be applied also for *collecting* "dirty water" from general waste-pipes, &c., and passing it into a drain in large bodies, instead of allowing each sink and lavatory to dribble into it at all points. The value of such an arrangement is considerable when the drainage is of *great* length, but the flushing-tank should in such cases be kept well away from the house, to prevent any bad air from its stagnant water becoming offensive. In such cases it is important to have a *clean* water flushing-tank * in addition, so as to thoroughly cleanse the drain—that is, to *fully* charge the drain with clean water—or it may get fouled by the discharges from the foul-water flush-tank, where it would not be cleansed again: the remedy would be worse than the disease. This tank, or "syphon," is also very

* A flushing-tank, as Fig. 123, holding about 100 gallons of water, is discharged in about half a minute. This gives a 6-inch drain a good scouring flush. The supply of water to the tank can be so arranged by a bib-cock, or other means, that the tank shall only empty itself once in twenty-four hours. Messrs. Bowles, Scott, and Read are the manufacturers.

valuable for emptying cesspools; but that is *engineering*, and going beyond our subject, and if I take you into such *preserves* we may all get taken up for trespassing.

Drain-flushing Important.

I have dwelt at length on waste-pipe, soil-pipe, and drain-flushing, as the wholesomeness of such drainage arrangements is of the very highest importance. Without this, no house is safe to live in; with it, the humblest cottage may be made a "sweet home." And I have enlarged upon the means for keeping all such drainage pipes wholesome, because our present method of ventilating such conduits makes it absolutely necessary that they should be kept well cleansed. Every waste-pipe, every soil-pipe, every drain and branch-drain is, or should be, ventilated, and these ventilating-pipes are carried up above the roofs of our houses, and if the drainage is not kept well flushed out with water, the stink coming out of these multiplied pipes will be enormous. No man with a very sensitive nose could stay for five minutes on the roofs of some of the hotels and club-houses of London.

Bad Air from Ventilating-pipes.

I remember some time ago putting my nose over the air-pipe from a bath and lavatory-waste, and the stink coming out of it was awful—enough to "knock one down," as we say sometimes.

The Atmosphere Polluted.

This is a very important matter; for though such ventilating-pipes may be carried well above

the roof, the smell coming from them where the drainage-pipes are not thoroughly flushed would be so great that the whole of the atmosphere surrounding our dwellings would at times become largely charged with the bad air emitted from such pipes. People suffering from all kinds of diseases would use the water-closets, or excremental matter coming from them would be thrown down such places, and the bad air from such matter adhering to the sides of the pipe, or left unwashed out of the drain, would escape through the ventilating-pipes to the air passing over the house; and though such bad air would no doubt get largely diluted before it was breathed, in great cities—at any rate in a huge city like London—it would pass at times pretty freely into houses. When the drainage of London houses is properly ventilated—*i.e.*, when every waste-pipe, soil-pipe, and drain has its ventilating-pipe, the number of such pipes will be enormous—hundreds of thousands: I might say a million, for there are nearly 600,000 private dwelling-houses in the metropolis.

London Drainage Ventilated.

How important, therefore, that the stink from such pipes shall be minimised! Well, where the plumbing and drainage are done on sanitary principles, this is done by good arrangement and good water-flushing, and where these do not exist such pipes will be found shooting out their venomous filth from behind chimney-stack and parapet, and from all points of the ridge to which they are

carried, to contaminate the air we have to breathe.

Services to Sanitary Fittings.

WATER SUPPLY TO SANITARY FITTINGS.—As service-pipes are the means generally employed for sending water through the various sanitary fittings of a house to cleanse them, as well as to cleanse the traps, pipes, and drainage from them, I ought, perhaps, to say a word on the sizes of such pipes. When such fittings can be filled with water (as baths, sinks, and lavatories), the size of the service-pipe is not so important, except for saving time ; for the fittings or vessels can be filled with water and the plug pulled out, or waste-arrangement opened, and the contents of the bath, sink, or lavatory, &c., sent through the waste-piping in good cleansing flushes—provided that the way into such pipings is equal in area to the diameter of the waste-pipe.*

Service-pipes to W.C.'s.

WATER-CLOSET SUPPLY.—The service-pipes to water-closets should be of such a size that a flush of about three gallons of water can be sent through them in about five seconds. Where the *head* of water is insufficient to allow an inch or

* A lavatory was fitted up on a stand to prove that lavatory-wastes are easily kept wholesome by good appliances. A short length of glass piping, $1\frac{1}{2}$ inches diameter, was attached to the waste-pipe of the lavatory, which had a $1\frac{1}{2}$-inch patent cast-lead trap under it. Though the inside of this piping was well coated over with plumbers' soil, the pipe was easily cleansed by *half*-filling the basin with water and discharging it through a "feather-waste-valve."

an inch-and-a-quarter pipe to do this, fix $1\frac{1}{2}$-inch or 2-inch pipe, and see that the "attached" supply-valve of the water-closet apparatus is of sufficient size to allow the full charge of the service-pipe to pass through it to cleanse the closet. Water waste-preventing valves are now made in large sizes, so as to get the two gallons of water out of their small cisterns as expeditiously as possible. I have no faith in so-called water-waste-preventors for supplying closets and urinals.

URINAL SUPPLY.—The supply of water to urinals should always be very copious, and where this cannot be given no urinal basin should be fixed, at any rate *inside* a house; for sooner or later it would become a nuisance. Urine and greasy water are the two great evils to contend against in perfecting the sanitary arrangements of a house. The nearer, therefore, such fittings as urinals and scullery-sinks are kept to the sewer or cesspool—for shortening their length of drainage—the more wholesome will be their waste-pipes and drainage, for they will be easier cleansed. Supply to Urinals.

Urine is difficult to treat, as it cannot be caught like grease and made to float, for it settles down upon everything it touches or comes into contact with. It can only be got rid of by copious flushes of water, and that too before it has time to settle down upon the urinal, trap, waste-pipe, or

drainage. Therefore, when this corrosive matter is passed into a vessel and its belongings, plenty of water should go with it to carry it right away. It would be very valuable if the contents of chamber-utensils and urinal basins could be passed directly into the running water of the sewer without having to pass through any waste-piping or drainage. As this cannot very well be done, an arrangement should be adopted where water is plentiful for

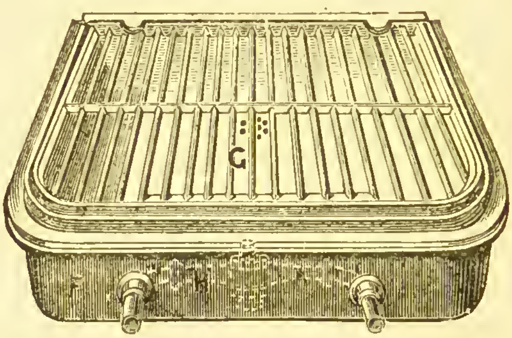


Fig. 124.—View of Treadle-Action Urinal Apparatus.

keeping a small body of water in the urinal-basin or basins, with a constant supply of water laid on, to largely dilute the urine before it passes into the waste-pipe; or a *treadle-action* supply-valve, as shown in Fig. 124, should be fixed, for a stream of water to pass through the basin and piping *during the use of the urinal.* A *self-acting* flushing apparatus* can be fixed, for flushing out a urinal or urinals every quarter of an hour, or at a shorter

* We have one in our factory, and it answers remarkably well.

or longer period; and with a Field's Annular Syphon *adapted* to the waste-pipe of the urinal basin or basins, or to the basins themselves, the flush of water through the basin or urinal could be made to start the syphon, for the contents of the basin or basins to pass into the drainage pipes simultaneously with the flush of water from the self-acting apparatus.

Scullery Sinks.

DISCHARGES FROM SCULLERY SINKS.—Grease can be arrested and kept out of a drain

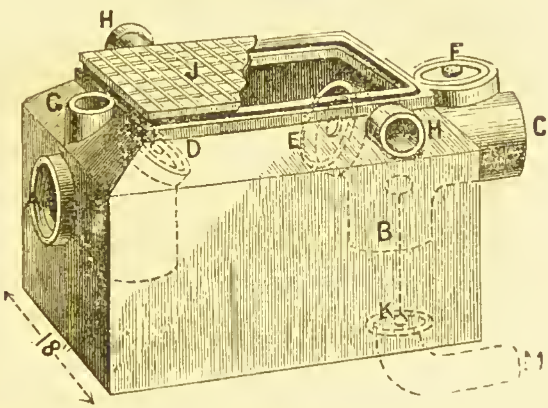


Fig. 125.—View of Patent Grease-intercepting Tank

with proper care. The discharges from a scullery sink should be made to pass through a tank of cold water, as shown in Figs. 125 and 126, for arresting the grease in it before passing into the drain. Or in *large* mansions, where a *great deal* of cooking is done, and especially where there are *long* lengths of drainage from them, the waste-pipe from a scullery sink might discharge into a larger tank than shown in Figs. 127 and

128, say a slate or lead-lined trough from 6 to 10 ft. long—according to the requirements—and about 18 inches wide at top and about half that width at bottom, and about 18 inches deep.

This grease-catching trough should be fixed in some convenient place outside the scullery, and the waste-pipe from the sink taken into it at one end below the water-line—which should be about a foot up from the bottom—and the outlet should be at

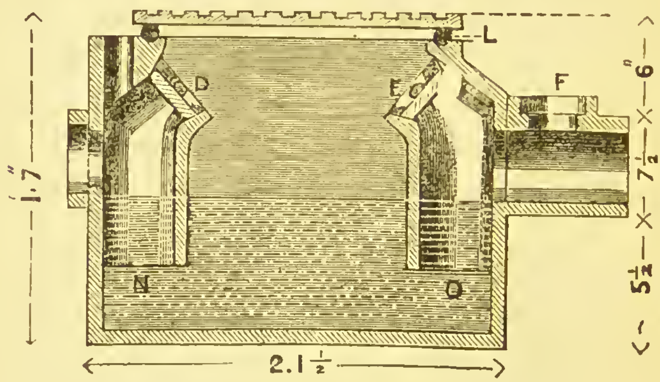


Fig. 126.—Section.

the other end. In a discharge from the sink the grease would be arrested in its transit through this cold body of water in the trough, and would float to the top. The body of grease congealing from day to day, and floating on the top of the water in the trough, could be cleaned out and cleared away weekly, and the trough well washed out; and thus the drains would be kept free from such adhesive matter as grease, and rendered more wholesome.*

* The "grease-intercepting tank," illustrated in Fig. 125, is found to be very valuable for arresting grease. Layers of grease

Pipes Protected from Frost

PIPE-FREEZING.—It will not be going out of our way to say a few words on *pipe-freezing*, now that we are speaking of service-pipes.

No service-pipe should be fixed on the external nor on the internal face of an external wall, especially a wall facing the north or east, without being cased in and thoroughly protected. When possible, service-pipes should be fixed on the cross-walls inside the house, and never on the main walls; for the cold penetrates through the external walls and, reaching any pipe fixed on its face, though inside the house, freezes the water in it. If a pipe *must* come down on the internal face of a main wall, then an inch board should be put between the pipe and the wall, and the pipe cased up, and the casing filled with cocoa-nut fibre. All service-pipes in roofs should be boxed in, and the boxes filled with this fibre. I do not like sawdust, for that decays; nor hair-felt, for that rots; and besides, to cover pipes with such material where bad air could reach it would be to harbour smells, for the effluvia coming from persons using the water-closets would hang about such stuff and cause it to become "stuffy." Where the service-pipe could not be boxed or cased in, and where the cold air could reach it—

3 and 4 ins. thick can be cut out of it after it has been in use from a week to three weeks—according to the work it has to do; but as I have explained its working in "Dulce Domum," I will say no more about it here.

as, *e.g.*, under water-closet seats, where the pipe has to leave the casing to reach the supply-valve of the water-closet—the pipe should be bound round with two or three thicknesses of gaskin ,and then be covered over with canvas, to protect it from frost. The cold air coming in through the overflow-pipe of the safe, and blowing upon an unprotected pipe, would soon freeze it.

If the positions of service-pipes are carefully considered, and the parts of questionable security protected in the manner described, no service-pipe in English houses need get frozen.

Water. Place of Storage.

STORAGE OF WATER.—Service-pipes lead me to water and its storage. But our time is now on the very verge of departure ; I will therefore say but one or two words upon this. As a "constant supply" in London means a little fickleness now and then—a shutting-off for 12 or 24 hours for "special repairs" or "alterations," &c., or to show how *empty* at times all things become—it is wise to have a place of storage. This place of storage is of the utmost importance for storing water for *dietetic* purposes. It should be so stored that no bad air from the house, water-closet, ventilating-pipe, dust-bin,* or any other place where vitiated air can come from, could reach it, to contaminate it. Though lead-lined cisterns are

* The dust-bin is generally a plague-spot ! No house is sanitarily perfect with an offensive house-refuse collector left in or near it.

very suitable for supplying water-closets, I have a preference for slate cisterns for storing water for dietetic purposes; of course such cisterns should have "safes" under them, as a protection against condensation, breakage, &c. I don't know that galvanised iron cisterns are so much more safe than lead; for the galvanising comes off, if it is not dissolved, and is consumed with the water. The action of water upon lead depends to a great extent upon the character of the water, and when this is known it can readily be determined whether it would be safe or not to store it in lead cisterns for drinking purposes. I have known lead cisterns eaten through in a year or two, and though the lead dissolving in this way in small quantities may have been mixed with large quantities of water, it could not but be injurious to store water for dietetic purposes in such cisterns. On the other hand I have seen lead-lined cisterns after they have been in use for half a century with the lead in them but slightly wasted.

Slate Cisterns.

Galvanised Iron Cisterns.

Lead Cisterns.

In executing the plumbing at Messrs. Child's * new banking premises, just erected (opposite the much-talked-of Griffin—which after all may be only meant for a turtle or its nightmare effects—to mark the spot where once Temple Bar stood), we repaired and refixed a *lead battened cistern*, belonging to Messrs. Child & Co., made in 1679, and which has been in use ever since, and, I

* The oldest banking-house in London.

should say, it will last for centuries more, for the water has not much affected the lead. This proves that lead is proof against certain waters. As many plumbers have never seen a lead battened cistern, and as they are not made now, I have had this old cistern illustrated in Fig. 127.

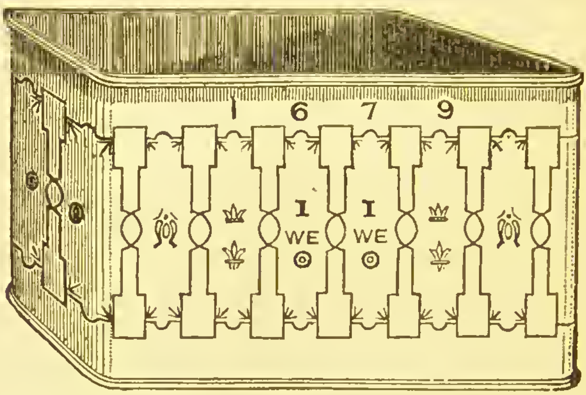


Fig. 127.—View of an old Lead Battened Cistern.

In new lead-lined cisterns, with some waters especially, a film is formed over the face of the lead. This is very valuable, as it prevents to a very great extent any further action of the water upon it. In cleaning out such cisterns, a soft hair-brush should be used, so as not to scratch off any part of this film.

Dr. Sedgwick Saunders' Pamphlet.

ON THE ACTION OF WATER UPON LEAD PIPES.—By permission of Dr. Sedgwick Saunders, F.S.A., Medical Officer of Health and Public Analyst for the City of London, I have made the following extracts from his recent translation of M. Belgrand's essay on "The Action of Water

upon Lead Pipes." In his introductory remarks, Dr. Sedgwick Saunders says:—"The action of waters upon lead had been long recognised by chemists of all countries, and before the appearance of M. Belgrand's brochure much had been written upon the subject, and the chemical conclusions enunciated by him anticipated by a general consensus of scientific opinions. . . In H.M. Navy the water tanks are not galvanised, but the interiors are occasionally lime-washed; it having been found that with galvanised* pipes the water becomes impregnated with zinc, which may be seen as a white film floating on the surface."

"Lead has been employed in the manufacture of conduit pipes ever since the distiibution of water in towns was first established by the Romans, the first aqueduct, the Appian, according to Varro,† being constructed in the year of Rome 442.

"From that period leaden pipes have been in constant use; all the water services in the interior of ancient towns being made of that metal.

"In Paris the leaden *branch-pipes* connecting dwelling houses with the main supply number about 39,500, and their average length may be put at 40 mètres,‡ and their total length at 1,580,000 mètres.

"In the case of houses that are occupied, the longest period for the water to remain in the leaden pipes can be estimated thus:—

Houses having unlimited supply . . .	9 hours during the night. from 5 to 10 min. during day.
Gauged supply . .	from 3 to 6 hours at the most.

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* Where the water would be likely to act upon lead, I prefer *slate* cisterns, and wrought-iron steam-pipes, protected by the Bower-Barff rustless process, for supplying water for dietetic purposes. We have used a large quantity of this piping.—S. S. H.

† Varro, *Marcus Terentius*, a learned writer at Rome, B.C. 116. —W.S.S.

‡ A mètre is 39·263 inches English.—W.S.S.

"As will be seen further on, the time the water is in contact with the interior surface of the pipe is too short for the lead to be attacked.

"I have already stated that in the net-work of main pipes there are about three kilomètres* of lead piping. These are from time to time removed, and on examination their interior surfaces are invariably found to be perfectly smooth and without any trace of corrosion.

"I now exhibit two pieces to the Academy: one comes from the service-pipe of the Faubourg Saint-Antoine, laid down in 1670, at the time when the pump of the Bridge of Notre Dame was erected; it is therefore more than 200 years old, and in the interior the impression of grains of sand is still to be seen. The other was taken up from a side street of Saint-Germain Market; it is somewhat less old, but equally unblemished.

"It may be added that the leaden pipes become firmly and rapidly coated with a thin crust† which prevents the water coming in contact with the lead.

"The harmlessness of leaden pipes appears to me proved by these facts, which explain why they are in use in all the towns of France, and in most European cities, without ever having given cause for complaint.

"M. Le Blanc has undertaken other experiments, by leaving the lead in water for a much longer period (than nine or ten hours). I quote his own words:—

"'ON THE ACTION OF WATERS UPON LEAD.

"'Chemists have long known with what facility lead becomes oxidised when immersed in distilled water in contact with air. Very small white shiny crystals of the hydrated oxide of lead are very rapidly formed, their quantity augmenting until a copious sediment at the bottom of the vessel has formed; the same obtains with pure rain water.

"'On the contrary, water containing a given quantity of salts, principally from selenitic wells, does not attack the lead under the same conditions at all.

"'Such are the results of experiments made by Professors of Chemistry during the last 40 years in public lectures, and M. Dumas never omitted to place them before his class at the Sorbonne.

"'Chemists have often remarked upon the harmlessness of lead with regard to potable waters, circulating in pipes of this metal, because of the *saline* matters which preserve the metal from oxidation.

"'No doubt it would be difficult to give an explanation of these facts, but they seem of the same kind as those which have been established with regard to iron, which can be preserved without oxidation in distilled water, even when aërated, if only a few drops of an alkali be added to it, whilst it is oxidised rapidly in pure aërated water. But it is curious to observe that by augmenting to a certain extent the proportion of alkali, oxidation can be facilitated.

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* A kilomètre is 1,000 mètres.—W.S.S.

† Carbonate of lime.—W.S.S.

"'Which salts are the most efficacious, when present in minute quantities, in preventing oxidation of lead in contact with water? Salts of lime alone are unquestionably so, even in the smallest proportions; in the absence of lime other salts are capable of protecting lead, in quantities of 0·1 gramme per litre. Nevertheless, after from 24 to 30 hours the water becomes faintly coloured by sulphuretted hydrogen; but this oxidation soon ceases. The following experiments were made to ascertain the particular influence of different salts.

"'Solutions were made with sulphate of soda, chloride of sodium, chloride of potassium, sulphate of magnesia, the strength of each solution being 0·1 gramme per litre. The lead was immersed in these for 24 hours, when the water became coloured by sulphuretted hydrogen, but the solvent action did not continue, and it may be said that the solutions in question are without notable action upon lead, for, at the end of 10 days, the re-agent did not produce any real precipitate.'

"Upon the whole there is absolutely no danger of poisoning from the use of water flowing through leaden pipes.

"Furthermore, in the *Journal des Savants* (October, 1871 p. 488), one reads: –

"'It may not be inopportune to draw attention to a fact not sufficiently known to the public—namely, that rain waters alter leaden and zinc vessels more than waters containing salts in solution, well waters for example. The result of this is that *these latter waters may remain in a leaden vessel without attacking it, and without becoming poisonous, while rain waters, free from saline matters, dissolve oxide of lead and thus become poisonous.* This observation, quoted from Guyton de Morveau, is perfectly true. I have verified it at the time of my investigation on the waters of the Bièvre.'"

Strength of Lead, and Dimensions.

CISTERN-LINING.—Before leaving the subject of water supply, I will describe the mode of *lining wood cisterns with lead.* Wood cisterns of any shape or size can be lined in their places with sheet lead of any weight per superficial foot, for lasting a few years or a century. The bottoms should be 1 lb. (or 2 lbs.) per foot superficial heavier than the sides; but 7-lb. bottoms and 6-lb. sides make good cisterns, though I prefer stronger substances—viz., 8-lb. bottoms and 7-lb. sides. In taking the dimensions, for cutting out the lead, all the sizes wanted are the length, width, and depth of the wood cistern inside. The bottom should be cut out 1-inch larger each way than the

T 2

cistern, to allow for squaring, straightening, and turning up at the edges, for "wedging" in at the angles of the four sides; *e.g.*, a cistern 6 feet by 5 feet and 3 feet 6 inches deep would require a piece of lead for the *bottom* 6 feet 1-inch by 5 feet 1 inch. These dimensions, added together, will give the *length* of the first side and end (though the first side and end to be put in is wanted 1½-inch longer than the last, to allow for the return edges on to the wood, the two pieces are generally cut in equal lengths, to save time and trouble); thus 6 feet 1-inch × 5 feet 1-inch.=11 feet 2-inches. This allows for squaring and straightening the ends, and for returning about three-quarters of an inch at each end on to the wood sides, for securing the lead in its position. The *width* is obtained by adding 3 inches to the depth of the cistern, to allow for straightening the edges, turning three-quarters of an inch on the bottom (though many plumbers use an inch for this) and 2 inches to cover the top edge of the cistern.

Order of Lining.

I will follow the order of lining and speak of the sides first. Unroll the lead upon the floor adjoining the cistern to be lined, or if the cistern is in a roof and there is no floor, then upon some boards, and dress out any irregularities in its surface, and, before lining out the sizes, see that the cistern is perfectly square; for carpenters, like other people, do not always work on the "square." When a side and end are in one piece, as we have been considering, and as is the practice, except in

very large cisterns, when a separate piece is used for each side and end, line out the sizes upon the lead, allowing a margin of about three-quarters of an inch to stand on the bottom, and also for the *returns* at the two ends. The line for turning up the end, for forming the upright unsoldered angle, should be marked with a chalk-line, and never scratched with a sharp tool. Having marked out the side and end, take a piece of quartering, or "straight-edge," and turn up the edge for standing on the bottom. This is easily done by kneeling on the piece of quartering, to keep it stiff, and turning up the edge with the aid of a chipping-knife and dresser. Then break up the end by placing the piece of quartering upon the line for the upright angle, and boss up the bottom corner a little, for fitting tightly into the angle of the wood cistern. Some plumbers stupidly cut this corner, and in such a way as to leave a hole just where the solder can run in, and so get themselves into trouble when soldering the cistern. In putting this piece of lead into its place in the cistern, bulge the centre part of the side and end inwards a little towards you, as you stand in the cistern, so as to be able to drive the angles of the lead tightly home. Be very careful with the *turned-up* angle, the *un-soldered* angle, and see that it fits *tightly into the angle of the cistern, before securing the lead at the ends;* for if the lead is not *well home* in such angles, when the side and end are fixed, and the dresser is used for driving it home, as is often

Sides and Ends.

done by unskilled men, the lead is very much weakened. I have known 6-lb. lead reduced to 4-lb. in such angles, and even for the edge of the dresser to be driven right through the lead, and the angle to require soldering. A nail in the *return* edge of the underlap, about 3 inches down from the top, is all that is wanted to secure the lead in its place. The edge of the lead is readily turned over the top of the cistern with a few sharp strokes of the dresser and fastened (the inner edge of the wood being rounded off a little before lining the cistern), and the stand-up part of the angle is easily bossed back. When forming this angle, the part to be bossed over the edge of the cistern should never be cut in, with the edge of the dresser or any other tool, or it will not boss over freely. The other side and end are put in in a similar way. The narrow pieces, or edges, returning upon the side and end already lined, should be carefully cut off with a chipping-knife when the lead is in its place, leaving about $\frac{1}{8}$th of an inch for driving into the angle—for *wedging* the jointing and preventing the solder going between the two leads. The sides and ends being lined, the bottom follows. Before lining the cistern, see that all the holes are cut in it for the pipes, especially the waste-hole (allowing sufficient size in the latter for opening the end of the pipe to receive the brass washer), and well counter-sink round the hole. Turn up the edges of the bottom in a rounding form, so as to

The Bottom.

allow the lead to stand up a little at each of the four sides, and boss up the corners of the bottom, so as to have a reserve of lead at such points for dressing into the corners of the cistern angles; then put the bottom in its place, and dress the lead well into each angle with the aid of the dresser and chase-wedge. Cut off the edge of the lead standing up against the sides, so as to leave about $\frac{1}{8}$th of an inch stand-up, for well wedging the lead into the angle. The cistern now being lined, soil a margin of 4 inches or 5 inches on each side of the angles to be soldered, and, when dry, shave the angles. The shaving on the bottom, F, Fig. 129, should be about $\frac{1}{4}$ inch wider than on the sides, G; the upright angles, Fig. 128, should be of equal width each side. The shaving should not extend beyond the solder, for the lead is weakened with wide shaving, especially when the solder is wiped off from it again. In shaving the lead be very careful *not* to *dig* the point of the shave-hook into the lead and so reduce its substance; simply shave the lead to brighten it, that the solder may readily *tin* upon it. Pull the point of the shave-hook along on the edge of the lead at the joining, so as to *close up* any space between the two leads, to prevent the solder getting in between them when soldering the cistern. Having shaved the angles, and greased them, to prevent tarnishing, punch in the edges, about every 9 inches, with a *bright* punch, with, say, $\frac{1}{4}$-inch face, or other bright

Shaving.

instrument, for securing the lead in its place, as shown by the *dotted line* in Fig. 128, but do not put a single nail into the angles, or you will have some trouble in soldering over the heads, for they are sure to "blow." The upright angles must be soldered first. If you cannot pour the metal upon a cloth or stick, and guide it into the angle in that way, you can splash the solder into

Soldering.

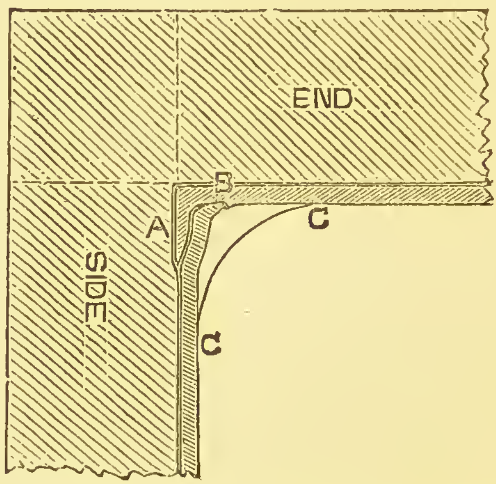

Fig. 128. Section of Cistern Soldering. Upright Angle.

the angle from the ladle with a splash-stick. Splash the solder very rapidly up and down the angle, and pull it up now and then with the splash-stick, and keep it in its place; and when you have a good body of solder in the angle, from the bottom to the top, take a well-heated and well-cleaned iron, and draw it up and down the angle, "patting" the solder into its place, then wipe down the angle *quickly*, pressing the cloth

hard upon each edge of the soldering with the points of the fingers, so as to get clean wiping. In finishing off the upright angle at the bottom, pull away all the fallen solder, and well under-cut the angle with the shave-hook, for easy joining when wiping in the bottom. Having wiped the two angles, the bottom comes next, and with plenty of

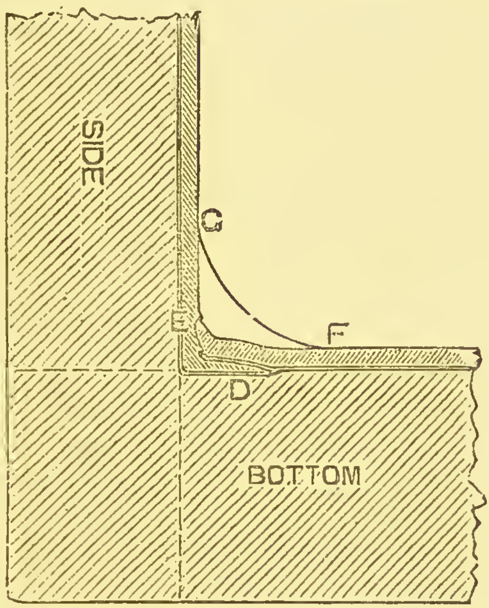

Fig. 129. Section of Cistern Soldering. Bottom Angle.

solder, and two or three irons, this is soon done. Chalk over a little of the bottom of the upright angles first, to prevent the solder adhering to them. Some men take many more irons to solder a cistern than others, but a skilled man ought to wipe out the cistern mentioned above with 6 irons—2 for the angles, and 4 for the bottom; such a cistern *ought* to be lined and soldered in

about 10 hours. Some plumbers make the return edges, the under-cloaks, too wide or too narrow. When such is the case it is impossible to get nice clean edges of soldering, for the edge of the lead is sure to make the face of the lead covering it irregular, however much it may be feathered off with the shave-hook. When the edge of the lead stands as shown in Fig. 129, the shaving-line is well outside the line of the edge, and is therefore free from any irregularities—*i.e.*, the return edge on to the wood should be under, say, $\frac{3}{4}$ inch, or over $1\frac{1}{2}$ inch. Fig. 128 shows a section of the upright angle (half-full-size), and Fig. 129 a section through the bottom angle, to the same scale.

Cisterns without Water.

Cisterns are of very little use without water. It may be interesting to many if I say something on the supply of water to London, past and present. I have culled some extracts from Stow's "Survey of London" (A.D. 1598), which are here appended, and I add to that a lengthy extract from an interesting article on the "Metropolitan Water Supply" in *Whitaker's Almanack* (1882), by permission of Mr. Whitaker. I have also appended some extracts from the London Water Companies' Regulations.

London Water Supply from the time of William I.

"Antiently until the Conqueror's time, and 200 years after, the Citie of London was watered, besides the famous river of Thames on the south part, with the river of the Wells, as it was then called, on the west, with a water called Wallbrooke running the midst of the Citie into the river of the Thames, serving the heart thereof, and with a fourth water or bourne which ran within the Citie through Langboorne ward, watering that part in the east. In the

West suburbs was also another great water called Oldborne, which had its fall into the river of Wells.

"Then was there three principal fountaines or wells in other suburbs; to wit, Holy Well, Clement's Well, and Clarke's Well. Neare unto this last-named fountaine were divers other wells; to wit, Skinner's Well, Fag's Well, Tode Well, Loder's Well, and Rad Well, all which sayde wells having the fall of their overflowing in the foresayde River, much increased the streame, and in that place gave it the name of Wells.

"In West Smithfield there was a poole in Recordes called Horse-poole, and one other poole neare unto the parish church of Saint Giles without Cripplegate. Besides all which, they had in everie streete and lane of the Citie diverse fayre Welles and fresh Springs. And after this manner was this Citie then served with sweete and fresh waters, which being since decaid, other meanes have been sought to supplie. . . . .

"The river of the Wells, the running water of Wallbrooke, the Bournes aforenamed, and other fresh waters that were in and about the Citie, being in process of time, by encroachment for buildings and heightenings of ground, utterly decaid, and the number of citizens mightily increased, they were forced to seeke sweete water abroad. . . .

"At the request of King Henry III., in the 21st year of his raigne, one Gilbert Sandforde granted them liberty to convey water from the towne of Teybourne by *pipes* of *lead* into the Citie.

"The first *cisterne* of *leade*, castellated with stone, in the Citie of London was the great conduit in West Cheape, which was begunne to bee builded in the yeare 1285, and was supplied with water from these newly-acquired sources. . . . The towne upon Cornhill was *cisterned* in the year 1401. . . . . King Henry VI., in 1442, granted to John Hatherley, mayor, license to take up 200 sodar of leade for the building of Conduits of a common garnery and of a new crosse in West Cheape for the honour of the Citie."

"Notwithstanding the readier access to the well waters obtained by the multiplication of pumps and the still continued use of the Thames water carried up into the City, the Corporation found it necessary to go yet further afield in search of an additional supply; and, in 1543, an Act was passed to enable them to bring water from Hampstead Heath, St. Marylebone, Hackney, and Muswell Hill. It was not until 1568 that Thames water was raised by machinery for the supply of any part of the town; but in that year a gin, probably a horse-wheel, was constructed to supply a conduit near

the top of Dowgate Hill. Thus the Corporation of London, down to the reign of Elizabeth, regarded it as one of their principal duties to supply the town with water, and see to the erection and preservation of conduits, to which the poor could freely resort. Down to this period it must likewise be borne in mind that the City and its immediate suburbs formed the whole of the Metropolis.

"In 1581 or 1582 Peter Maurice, a Dutchman, obtained a lease from the City of the first arch of London Bridge on the north side, and erected a water-wheel to be worked by the tide, and a set of force-pumps to raise Thames water for the supply of the neighbourhood. The water was raised to the top of a wooden building 120 feet high, and passed from thence through lead pipes to supply the dwelling-houses in Thames Street, New Fish Street Hill, and Gracechurch Street as far as a standard on Cornhill, which was erected in the middle of the street where the four ways meet. The water which was to spare after supplying these streets, flowed from the standard through four pipes branching to Bishopgate, Aldgate, the Bridge and Walbrook, which supplied the dwelling-houses in the neighbourhood and cleansed the gutters in the streets. The site of the standard was supposed to be the highest ground in the City. The quantity of water raised was equal to about 3,170,000 imperial barrels per annum, or an average quantity of 216 gallons per minute. There were sixteen pumps worked by this wheel, each of 7 inches diameter and 30 inches stroke. In 1583 or 1584 machinery was fixed in the second arch.

"In 1594, for the better supply of the City, Bevis Bulmar erected a large horse-engine and four pumps at Broken Wharf, to raise Thames water for the inhabitants of Cheapside, St. Paul's Churchyard, Fleet Street, &c., which was removed previous to 1756 on account of other companies being able to supply water at a cheaper rate. This appears to have been the latest employment of animal power for the purpose. The New River,* the greatest and most splendid work that was ever undertaken for the supply of a modern city with water, was commenced in James I.'s reign. In 1605, the third year of his reign, the supply of water was found to be inadequate to the wants of an increased population, and, as that at time the discovery of the steam-engine had not been made, it was necessary to seek abroad for more powerful springs of water than had hitherto been discovered, and at a sufficient elevation to allow the

* The district supplied by the New River Company (1882) is bounded on the east by the Tower, on the west by Charing Cross, on the south by the Thames, and on the north by Hertford. Constant supply is given in Shoreditch, Edmonton, and various other places.—S. S. H.

water to run to London. These were met with in the neighbourhood of Hertford, above twenty miles north of London, and the citizens conceived the vast plan of bringing these springs by means of a channel to Islington, and for that purpose obtained an Act of Parliament empowering them to bring a stream of water from the springs of Chadwell and Amwell, in the county of Hertford, between the towns of Hertford and Ware. Surveyors were employed by the City to plan the execution of the work. In the following year a further Act was passed, giving additional power with regard to the acquisition of land, &c., but the work was not completed until some years after.

"In 1608 Sir Hugh Myddelton, citizen and goldsmith, offered at his own charge to carry the Acts of James into execution. In 1610 the citizens, by an Act of Common Council, made over their powers to Sir Hugh Myddelton, and in 1612 this Act was confirmed by an indenture. The work was completed, and the water admitted into the basins at the New River head at Michaelmas, 1613. In 1619 a charter of Incorporation was granted by James I. to Sir Hugh in conjunction with other wealthy citizens, and they were styled 'The Governor and Company of the New River brought from Chadwell and Amwell to London.' The King subscribed towards the undertaking, and was thereby entitled to a moiety of the profits. The work was said to have cost £500,000. The capital was divided into seventy-two shares, of which the King had thirty-six, but so poorly did the scheme at first answer that Sir Hugh Myddelton, who had spent the whole of his fortune, was ruined, and the proprietors did not for thirty years divide more than £5 per share, or about 1*s.* 6*d.* per cent. It should here be added that previous to the year 1738 the supply from the springs was found to be insufficient, and arrangements were made with the trustees of the River Lea to enable the New River Company to divert water from the said river. This was done first by pipes and afterwards by a cut and trough into the New River, the dimensions of which were determined by Act of Parliament passed in 1738, in the 12th year of the reign of George II. In this farming out of their functions by the Corporation of London to enterprising individuals we see the commencement of the existing system of works for the supply of water. The Municipality, however, did not for some time entirely relinquish the responsibility of the proper supply of its inhabitants. In 1654 the Court of Common Council passed an Act for levying on the inhabitants of the City two-fifteenths for sundry repairs of conduits, and for the employment of the poor in bringing water into the City. In 1681 four-fifteenths were raised for the like purpose. The old works at London Bridge,

too, were still in active rivalry with the New River; and, in 1701, having been purchased for £35,000 by one Richard Soames, he procured, to secure his property in the whole, a lease of the fourth arch for 381 years. Soames formed a company by 300 shares of £500 each, and to this company, in 1761, a further lease was granted of the third arch for 321 years, and in 1767 another of the fifth arch from the north end, and the second arch from the south end (the latter to be used for the supply of the Borough) for 315 years, so that all the leases would expire simultaneously in the year 2082! But this contemplated length of days was cut short in 1822 by the Statute of the 3rd of Geo. IV., cap. 109, which provided for the entire removal of the London Bridge Water Works, with a view to the improvement of the old bridge or the erection of a new one, and transferred the service of their district to the New River Company. It was, however, made a condition by the latter company that they should have a steam-engine to pump from the Thames in case of failure in the supply by the New River, and a 100-horse engine was accordingly erected at Broken Wharf.

"The Chelsea Waterworks were established in 1722. The Thames water was raised from settling ponds—in the first instance by a water-wheel, afterwards, in 1782, by one of Boulton and Watt's engines.

"In 1808, the East London Company purchased the Shadwell Works, erected about 1600, and which were eventually given up, the supply from the Company's new works being superior. This Company also purchased at the same time (1808), the West Ham Waterworks, which were set on foot in 1743.

"Previous to the year 1756 there was a horse machine for raising Thames water through a 7-inch pipe in Southwark, called the Bank End Waterworks. A company was formed in 1758 under the name of the Old Borough Waterworks Company, which, together with the London Bridge Works, supplied Southwark. A steam-engine was afterwards erected; and, in 1823, upon the removal of the London Bridge water-wheels, the two works were consolidated under the name of the Southwark Works, and became the property of John Edwards, Esq. Rotherhithe and its neighbourhood were supplied by works erected in or about 1756.

"In 1785 the Lambeth Waterworks were established, to supply the district upon the south side of the Thames, exclusive of the parishes of St. George and St. Saviour, Southwark.

"In 1871 the Metropolis Water Act was passed, which, after providing that every company shall supply water on Sundays as on other days, relates principally to the conditions under which a constant supply is to be given to the Metropolis, and various powers

were given to the Board of Trade by that Act. In the session of 1872 it was resolved to transfer the powers conferred upon the Board of Trade to the Local Government Board, and, on January 1, 1873, that Board took over the duties and responsibilities of the Board of Trade.

"In his last annual report (1880) Lieutenant-Colonel Bolton, the water examiner appointed under the Act, reported favourably upon the efforts made by the several companies during the year to maintain and extend a proper supply of water in their respective districts, and he states, 'It is satisfactory to learn that all the companies without exception are now, to a certain extent, giving constant supply.' This circumstance derives importance not only from its bearing upon the convenience and sanitary requirements of the consumers, but from the increased facilities thus afforded for the extinction of fires in the Metropolis by enabling hydrants to be fixed in suitable places and at short intervals. With respect to the quality of the supply, the report is less satisfactory. It represents the state of the water in the Thames and Lea during the winter half of 1880 as generally bad. Dr. Frankland also stated that never, since he commenced, in 1868, to analyse it, had the water abstracted from the Thames been so much polluted by organic matters, and that, 'owing to the flooded condition of the river, even in summer, much filthy matter from sewers, cesspools, and cultivated fields was swept into it.' Of the Lea he observed that its pollution by organic matters, 'which has been steadily increasing since 1876, and already in 1879 was unprecedented, experienced a further augmentation last year, and exceeded that of the Thames

NAME OF COMPANY.	Solid Matters.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total combined Nitrogen.	Chlorine.	Total Hardness.	See note.*
THAMES—									
Chelsea	28·02	.212	·042	001	·175	·218	1·5	20·1	4·3
West Middlesex ..	28·36	·243	·043	·001	·210	·253	1·5	20·0	4·8
Southwark	29·66	·298	·049	·000	·196	·245	1·6	20·6	5·9
Grand Junction ..	28·70	·248	·048	·001	·188	·237	1·5	20·0	5 0
Lambeth	30·30	·288	·045	·000	·201	·247	1·6	20·5	5·6
LEA—									
New River	29·02	·177	·035	·000	·234	·287	1·6	20·5	3·6
East London	31·00	·238	·040	·000	·180	·221	1·8	21·0	4·7
DEEP WELLS—									
Kent..	43·05	·079	·015	·001	·427	.442	2·5	26·6	1·6

* Proportional amount of organic elements, that in the Kent Company's water during the nine years ending December, 1876, being taken as 1.

during all the previous twelve years, excepting 1872 and 1879.' His not unnatural conclusion is that 'the water both of the Thames and Lea, therefore, is becoming year by year less suitable for domestic use.' The filtration of river water does not seem to have had the effect of depriving it of all its impurities. According to Dr. Frankland, out of 142,190,971 gallons supplied daily by the Metropolitan water companies during 1880, about one-half, or 71,897,776 gallons, was sometimes 'grossly polluted by sewage matter,' and only about one-sixteenth was 'uniformly of excellent quality for drinking,' whilst the residue, or 61,765,034 gallons, is pronounced to have been only 'occasionally' polluted. The water supplied by some of the companies from deep wells is stated, however, to have been 'uniformly pure and wholesome,' and it is evident that such wells afford the best means of obtaining a proper supply for drinking purposes. The preceding table shows the results of the chemical examination of the water supplied to the Metropolis during 1880. The numbers relate to 100,000 parts of each water.

"It will be seen from these figures that the river waters were much inferior in quality to the deep well waters.

"The average daily supply during the year 1880, for all purposes, gives a consumption of 32·46 gallons per head of estimated population, and 243 gallons per house, as will be seen from the following table :—

Name of Company.	Average of the Year.	
	Per Head, Gallons.	Per House, Gallons.
Kent	29·23	171
New River	28·21	215
East London	35·72	267
Southwark and Vauxhall ...	35·65	264
West Middlesex...	27·03	202
Grand Junction	33·63	302
Lambeth..	34·01	238
Chelsea	36·24	290
General Average	32·46	243

Estimated population, December, 1880 4,469,014
Number of houses, December, 1880 601,210

"The charges made by the different companies vary considerably. The New River, the Chelsea, the West Middlesex, and the Grand Junction companies charge £4 per cent. per annum on the annual value of dwelling-houses where such annual value does not

exceed £200, and £3 per cent. where the value exceeds that amount. This is for the supply of water for ordinary domestic purposes. If there be a water-closet or water-closets, or fixed bath or baths, or any high service, then each of these companies is entitled to charge sums varying from 4*s.* to 12*s.*, according to the annual value of the dwelling, for each single water-closet, bath, or high service, and from 2*s.* to 6*s.* for each additional water-closet, bath, or high service. *High service is taken to be* 10 *feet above the pavement.* The New River Company, when owners of small house property undertake the payment of rates, make an allowance of 10 per cent. in the case of houses for which the rate ordinarily payable would be above 20*s.*, and under 27*s.* per annum. Special rates are made by all the companies for certain supplies—such, for instance, as street-watering, usually charged by the superficial yard, and in some cases by meter, at an average charge of 1*s.* per 1,000 gallons, the supply of public baths and charitable institutions, the price in these cases varying from 4*d.* to 6*d.* per 1,000 gallons. The Southwark and Vauxhall Company make a charge for ordinary domestic service not exceeding £5 on the annual value of the property, and the Lambeth Company charge £7 10*s.* per cent. where the value does not exceed £20, and £5 per cent. on a value of £100; the remarks as to special rates also apply to these last-named companies. The various rates and charges which each company is empowered to make are fully set out in pp. 253 to 302 of Appendix I. to the Select Committee's Report on the East London Water Bills, Session 1867. There can be no doubt that the system of charging on the annual value is one of great unfairness to the ordinary consumer. It has been found by admeasurement that the water consumed by the occupants of houses of the 'unwealthy' classes does not exceed six-and-a-half gallons a day. In the higher class of houses there is of course a much larger consumption, but there is no reason to doubt that an average of twenty gallons a day per head is an abundant allowance for all domestic purposes, allowing even for considerable waste. Now, if we take a house of the annual rental of £200, the charge at present would be, for ordinary supply, £8; for two water-closets, bath, and high service it would be £1 8*s.*, making a total charge for the year of £9 8*s.* Allowing eight persons to the house, their annual consumption of water at twenty gallons a day would amount to 7,280 gallons each in the year. It has already been shown that the companies can supply water at 1*s.* per 1,000 gallons; and at this rate the cost to the occupier of the house would amount to £2 18*s.* 8*d.* per annum, or little more than *one-third* of the present charge. In the City the anomaly of the system is still more glaring. One case among many will suffice to illustrate it. A firm having an

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office not far from St. Paul's, use weekly but a few gallons of water, and pay for it on their rental of £350. At the back of this office is a small house inhabited by several laundresses, and they use, at the least, twenty times as much water as the firm in question, while they pay on a rental of about £30."

"REGULATIONS MADE UNDER THE METROPOLIS WATER ACT, 1871.

Weight of Lead Pipes.

"No lead pipe shall hereafter be laid or fixed in or about any premises for the conveyance of or in connexion with the water supplied by the Company (except when and as otherwise authorised by these regulations, or by the Company), unless the same shall be of equal thickness throughout, and of at least the weight following, that is to say :—

Internal Diameter of Pipe in Inches.	Weight of Pipe in lbs. per Lineal Yard.
$\frac{3}{8}$ inch diameter.	5 lbs. per lineal yard.
$\frac{1}{2}$,, ,,	6 ,, ,,
$\frac{5}{8}$,, ,,	$7\frac{1}{2}$,, ,,
$\frac{3}{4}$,, ,,	9 ,, ,,
1 ,, ,,	12 ,, ,,
$1\frac{1}{4}$,, ,,	16 ,, ,,

Interior Pipes.

"Every pipe hereafter laid or fixed in the interior of any dwelling-house for the conveyance of, or in connexion with, the water of the Company, must, unless with the consent of the Company, if in contact with the ground, be of lead, but may otherwise be of lead, copper, or wrought iron, at the option of the consumer.

Material and Joints of External Pipes.

"Every 'communication-pipe,' and every pipe external to the house and through the external walls thereof, hereafter respectively laid or fixed, in connexion with the water of the Company, shall be of lead, and every joint thereof shall be of the kind called a 'plumbing' or 'wiped' joint.

"Every 'communication-pipe' for the conveyance of water to be supplied by the Company into any premises shall have at or near its point of entrance into such premises, and if desired by the consumer within such premises, a sound and suitable stop-valve of the screw-down kind, with an area of waterway not less than that of a half-inch pipe, and not greater than that of the 'communication-pipe,' the size of the valve within these limits being at the option of the consumer.

"No overflow or waste-pipe other than a 'warning-pipe' shall be attached to any cistern supplied with water by the Company, and every such overflow or waste-pipe existing at the time when these regulations come into operation shall be removed, or at the option of the consumer shall be converted into an efficient 'warning-pipe' within two calendar months next after the Company shall have given to the occupier of, or left at the premises in which such cistern is situate, a notice in writing requiring such alteration to be made.

"Every 'warning-pipe' shall be placed in such a situation as will admit of the discharge of the water from such 'warning pipe' being readily ascertained by the officers of the Company. And the position of such 'warning-pipe' shall not be changed without previous notice to and approval by the Company.

"No draw-tap shall in future be fixed unless the same shall be sound and suitable, and of the 'screw-down' kind.

"Every draw-tap in connexion with any 'stand-pipe' or other apparatus outside any dwelling-house in a court or other public place, to supply any group or number of such dwelling-houses, shall be sound and suitable, and of the 'waste-preventer' kind, and be protected as far as possible from injury by frost, theft, or mischief.

"Every boiler, urinal, and water-closet, in which water supplied by the Company is used (other than water-closets in which hand-flushing is employed), shall, within three months after these Regulations come into operation, be served only through a cistern or service-box and without a stool-cock, and there shall be no direct communication from the pipes of the Company to any boiler, urinal, or water-closet.

"Every water-closet cistern or water-closet service-box hereafter fitted or fixed in which water supplied by the Company is to be used, shall have an efficient 'waste-preventing' apparatus, so constructed as not to be capable of discharging more than two gallons of water at each flush. Water-closet Apparatus.

"Every urinal-cistern in which water supplied by the Company is used other than public urinal-cisterns, or cisterns having attached to them a self-closing apparatus, shall have an efficient 'waste-preventing' apparatus, so constructed as not to be capable of discharging more than one gallon of water at each flush. Urinal-cistern Apparatus.

"Every 'down-pipe' hereafter fixed for the discharge of water into the pan or basin of any water-closet shall have an internal diameter of not less than one inch and a quarter, and if of lead shall weigh not less than nine pounds to every lineal yard. Water-closet Down-pipes.

Bath to be without Overflow-pipe.

"No bath supplied with water by the Company shall have any overflow waste-pipe, except it be so arranged as to act as a 'warning-pipe.'

Bath Apparatus.

"In every bath hereafter fitted or fixed the outlet shall be distinct from, and unconnected with, the inlet or inlets ; and the inlet or inlets must be placed so that the orifice or orifices shall be above the highest water level of the bath. The outlet of every such bath shall be provided with a perfectly water-tight plug, valve, or cock.

Weight of Lead-pipes having Open Ends.

"All lead 'warning-pipes' and other lead pipes of which the ends are open, so that such pipes cannot remain charged with water, may be of the following minimum weights ; that is to say :—

½-inch	(internal diameter)	. .	3 lbs. per yard.
¾ ,,	do.	. .	5 ,,
1 ,,	do.	. .	7 ,,

Ventilation of W.C. Rooms.

WATER-CLOSET ROOMS.—One word on the *rooms* where water-closet apparatus are fixed. If the walls of private water-closets are not covered with glazed tiles or made of glazed bricks, all public water-closets should be, so that they may be thoroughly washed out occasionally. Every water-closet should be ventilated—*i.e.*, fresh air should be brought *into* them, and means should be provided for the exit of the vitiated air.

The door of the closet should be made as air-tight as possible, and kept low, so as to prevent the effluvia coming through such doorways into the house. The higher the ceiling is the better, and the opening into the extracting shaft should be made at the highest part of the room. The walls under the water-closet seat, as well as the floor, should be *very carefully stopped*, so that not a crevice, crack, or opening may be left where the effluvium from a long seat-holder could es-

cape into an adjoining room.* When there are any pipe-casings passing through water-closets, as often occur, where water-closets are fixed in tiers, they should be sealed off so that the air of one water-closet may not pass to another, or a person using an upper water-closet at the same time a lower one is being used may wonder what is the matter with himself; for in addition to his own affair he would have the affairs of others, and you will agree with me that in such matters a man's own affairs are enough.

Code of Rules for House Sanitation.—Various opinions are now before the public for draining a house. Several have been referred to during these lectures, and without bringing others before your notice, I will simply say, in concluding these remarks on "The Science and Art of Sanitary Plumbing," that it is time that the opinions of sanitarians on such matters should be consolidated. Various Opinions.

The principles of house drainage are so far determined that there ought to be no great difficulty in framing a good sanitary code as a general basis to work from. Its boundary lines should be marked out with silken cords rather than with iron bands; for, like all new things, sanitary knowledge should have room to grow. It would be just as easy for a tailor to make a suit of clothes to suit all Opinions consolidated.

* Serious illnesses have occurred through such neglect. I know of many.

climates as it would be to lay down a code of rules to suit all cases.

If I had to draw up a code of rules, they would read somewhat as follows :—

Water and its Storage.

1. Pure water shall be supplied to every house for dietetic purposes ; and where this water cannot be drawn direct from a constant supply, it shall be stored in cisterns so placed that they can be easily cleaned, and that no vitiated air can reach them, either from the house, water-closets, or ventilating-pipes, from waste-pipes, soil-pipes, or drains.

Draw-off.

2. No draw-off cock to any sink or "fitting," other than a water-closet, shall be supplied from a cistern fixed in a water-closet, or standing in a place where any contaminated air can reach it, or from a cistern or service-pipe which also supplies a water-closet.

Drain Intercepted.

3. Every drain shall be trapped off from the sewer by a self-cleansing intercepting sewer-trap fixed outside the house ; and where the mouths or inlets of such traps cannot be left open to the atmosphere, air-induct pipes should be taken into the drain immediately on the house side of such traps.

No Drain Inside.

4. No drain shall enter the walls of a detached or semi-detached house.

Drains Inside.

5. In a line of houses, as in terraces, where it is impossible for the drain to reach the soil-pipes without coming inside the house, such drain shall be of cast-iron, heavy water-main strength, and this pipe shall be protected from rusting by the

Bower-Barff Rustless Process, or coated with solution, and laid in a brick trench, or fixed on the face of the basement walls, and its *joints well caulked with lead.* The drain shall be so ventilated that not a foot of it shall be without a free circulation of air through it.

6. Every drain from a house shall be so ventilated that no stagnant air shall remain in any part of it ; and where this cannot be done by air-shafts, ventilating-pipes shall be fixed, and the drain divided into sections, and its branch-drains (when of great length) localised, so as to ensure ventilation in the entire system of drainage. Drains Ventilated.

7. All soil-pipes, when practicable, shall be fixed outside the house, with their discharging ends exposed to the atmosphere—either directly by emptying into open traps, or indirectly by foot-ventilation ; and such pipes shall be carried up to the highest points of the roof full size, having their terminals well removed from all openings into the roof or house. Soil-pipes.

8. All dirty-water wastes from sinks, baths, lavatories, &c., shall discharge with open ends into intercepting-traps fixed outside the house, and such pipes shall be continued up through the roof full size for ventilation. Dirty water Wastes.

9. All "clean-water" wastes—from cisterns, cistern-safes, &c., shall be kept separate from other wastes, and shall discharge with open ends into the atmosphere away from all drain-traps or places where any bad air can reach them. Clean water Wastes.

Overflow-pipes.

10. All wastes, or overflow-pipes, from safes under water-closets, baths, &c., shall be kept separate from other waste-pipes and shall be made to discharge in the open air.

"Fittings" Trapped.

11. Every sanitary "fitting" inside a house where foul matter, or contaminated water, is passed into it or from it, shall have its waste-pipe trapped off from the house, and such trapping shall be made immediately under such "fitting."

Traps.

12. All traps fixed inside the house shall be self-cleansing; and no trap which fouls itself, or is not easily flushed out, shall be used on the drainage outside the house.

Traps Ventilated.

13. All traps to water-closets, slop-sinks, sinks, baths, lavatories, &c., which can have their water syphoned out by the use of any "fitting" upon a pipe in connection with them, or by the use of themselves, shall be ventilated, to prevent such syphonage, and to aerate the branch-pipes.

Sanitary Fittings.

14. No sanitary fitting shall be fixed which will not allow a good flush of water to be sent through it to cleanse it and its belongings, to prevent any pipe from it—be it a waste-pipe; soil-pipe, or drain—from getting unwholesome.

Flushing.

15. Every house shall be provided with efficient means for flushing out the whole of its drainage.

Walls of W.C.'s Air-tight.

16. The walls inside water-closet seats, the floor, and the walls of water-closets, should be made air-tight, to prevent any odours in them passing to any room adjoining, through a crevice, crack, or opening.

17. The rooms of water-closets should be well ventilated, so that a constant change of air may take place in them. W.C. Rooms.

Gentlemen! I have done—my task is ended; but before taking leave of you, allow me the pleasure of thanking you for your kind indulgence, for your patient hearing, and for the great interest taken in these lectures. I hope your time has not been wholly wasted, and though the public at large may be the greatest gainers by having healthier homes to live in, I trust some benefit will accrue to you individually. Whatever charge may be laid against journeymen plumbers, want of interest in their trade cannot be; for I question if any other branch of the great building trades would have come out night after night, during the hot time of summer, to listen to dry lectures. Conclusion.

Lying there in those strong arms of yours, slumbering in the hardened muscles, resting in the well-trained fingers and educated hands, lies the health of this leviathan city—at any rate to a large extent. The plumber's part in making a house, a town, a city *healthy* is enormous. Let the plumbing be done on the principles laid down in these lectures, and this huge city, teeming though it be with human beings, will become the healthiest, as it is now the greatest, city in the world. When commercial men want to feel the pulsations of business life, they come to London, for in it beats the heart of the world's industry. As the heart is

the seat of life, so let this city be the seat, the home, of sanitation.

All England on Monday last mourned the loss of the great and good Dean of Westminster.* High and low, rich and poor, prince and peasant, believers and unbelievers, felt that in the loss of that life a loss had fallen upon all classes. He has gone from our midst, but his memory dwells amongst us as that of one of England's noblest sons. And why was he universally respected and beloved ? Because all felt that he nobly strove to do his duty. Fearlessly and earnestly he did his work. He spared no pains, he shrank from no difficulty, he was dismayed by no obstacles. Workers of lead, manipulators of solder, men of metal, you may not occupy the same high position as the late Dean Stanley, your sphere of influence may not be so large ; but you may all be actuated by the same noble spirit, and this will in every age meet its reward. Let thoroughness, thoughtfulness, and honesty, with an earnest desire to do your duty, characterise you in all your works; let these works testify to your clear-sighted appreciation of the hygienic ends it is your duty to have in view ; and though your names be not written in lead, as are written the names of military heroes, your *works* will be in *lead* and will live. And the plumbers coming after you in the future years, when your fingers shall have lost

* According to the papers, *bad drainage* had a good deal to do with the Dean's death.

the cunning of the craft, and your hands the use of tools; these future plumbers, as they look upon your workmanship—your graceful bends, your well-made joints, your connections and disconnections—shall say, "What splendid plumbers these 19th-century plumbers were! How well they knew *how* to do their work, and how well they *did* it!"

DISCUSSION.—15TH AUGUST, 1881.

Extracted from "THE BUILDER,' *and* "THE BUILDING NEWS."

"MR. ERNEST HART presided, and in opening the proceedings read the conditions which have been laid down by the National Health Society for the working plumbers' competition for the prizes offered by the Society for the best specimens of workmanship in plumbing based on sanitary principles. Any one who desires to compete must fill up a form to be obtained from the National Health Society, 44, Berners Street, and all such forms must be returned by the 15th of September.

"Mr. Daniel Emptage, of Margate, led off the discussion by reading a short paper, in which he expressed his opinion that Mr. Hellyer's able lectures were calculated to do a vast amount of good in awakening interest upon the important subject of which they treated. He agreed in the main with Mr. Hellyer's remarks as to country shops, and with the advice given to young working plumbers to come up to London to improve themselves in their trade. At the same time, as a provincial man, he felt bound to say a few words on behalf of the plumbers of provincial towns, in many of which a very lively interest was taken in sanitary matters. In his own town there were many large scholastic and other establishments in which the sanitary arrangements were such as would be hardly found fault with even by Mr. Hellyer. As the result of a large number of practical experiments made during the last two years, he (the speaker) had arrived at the following conclusions with regard to trap-waving or syphonage, viz. :—1. That the S or P syphons are, when unventilated, very unsafe, from the fact that they are easily untrapped by waving-out or syphonage. 2. That the cast D, the "Eclipse," and the V traps hold their seals much more tenaciously than the syphons, but are still very liable under some conditions to become unsealed when not properly protected by ventilation. 3. That the old D is very much more difficult to untrap than any of the preceding traps; but even this, when without ventilation, is not safe from syphonage. 4. That the seal of a P syphon, even under the most favourable circumstances with respect to ventilation, is not safe against a rush of water passing rapidly through it. 5.

That a well-made ഗ trap, when properly ventilated, and fixed in connection with a fully-ventilated soil-pipe, is very difficult to unseal. 6. That the other four traps mentioned are, when properly ventilated, quite secure from either waving-out or syphonage, and they have the advantage of being so constructed that their connection with the soil-pipe could be made at a much higher level than was possible with the ഗ. They all have, however, the great disadvantage of being more foul. Mr. Emptage went on to say that, while thinking over the matter, it occurred to him that the ഗ trap might be so altered that, while retaining its non-syphoning qualities, it should at the same time allow of a connection with the soil-pipe similar to the others. He had such a trap made, and was very pleased to find it answer his expectations in every respect. In it he still retained the dome of the "out-go" as in the ഗ. He had subjected this new form of trap to the most severe tests, and found that when it was fully protected by ventilation it was quite safe from waving or syphonage. He had since patented it. With regard to ventilation, to properly ventilate a soil-pipe and trap, careful thought was required. The kind of apparatus, length of soil-pipe and vent-pipe, also the arrangements below the soil-pipe, must all be taken into consideration, because the diameter of pipe which would be ample for one arrangement would be quite inadequate for another. He was very much surprised to hear Mr. Hellyer say that he should be satisfied with a 2-inch vent-pipe, 50 feet or 60 feet long, to ventilate a soil-pipe and trap 7 feet long and open at the foot. He had practically tried such an arrangement fitted with the five traps before mentioned, alternately, and he found that the only trap which would be quite safe under such conditions was the D. The trap which required the most carefully ventilating was the plain round syphon, and that which required the least was the old D. There was, however, a great difference in the effect which ventilation had upon the two traps. With the syphon the water still rushed through, thoroughly cleansing the trap, and leaving it sealed with perfectly clear water, but the D retained more filth when fitted with an air-pipe than without one. He agreed with Mr. Hellyer in condemning the pan-closet, and the outcome of the experience he (the speaker) had gained since abandoning the pan-closet was that the direct-action closets, such as Phillips's "Sanitary," the "Artisan," the "Carmichael," and the "Vortex," were far superior to several of the more costly ones. Such closets, fixed in a proper manner, with suitable ventilation, and with a flush of two gallons delivered in five seconds, were, in his experience, unequalled for cleanliness. With regard to cowls, he had fixed several on soil-pipes and drains at Margate, both in exposed and sheltered

positions, and upon several he had made some careful observations. In one instance he found during a slight shuffy wind that Banner's cowl repeatedly stopped mouth to wind, at which times the smoke with which he was testing it escaped at the foot-vent. In another case he found that after the smoke had ceased to issue from Banner's cowl, it came up again if he removed the cowl, and ceased when he replaced it. He tried that three times with the same results. In both these instances he found the plain open pipe quite as effective as with the cowl—indeed, more so. From other observations, he was convinced that in cases where the ventilation of the soil-pipes and drains was so arranged that it mattered not whether the current of air passed up or down them, open pipes were best. There were, however, places where it was very desirable to, as far as possible, prevent down-draught, and in such cases cowls were sometimes very useful. In conclusion, Mr. Emptage urged upon all connected with the plumbing trade the necessity of giving increased study to the subject, and expressed his thanks to Mr. Ernest Turner for suggesting, to the National Health Society for promoting, and to Mr. Hellyer for delivering, the lectures.

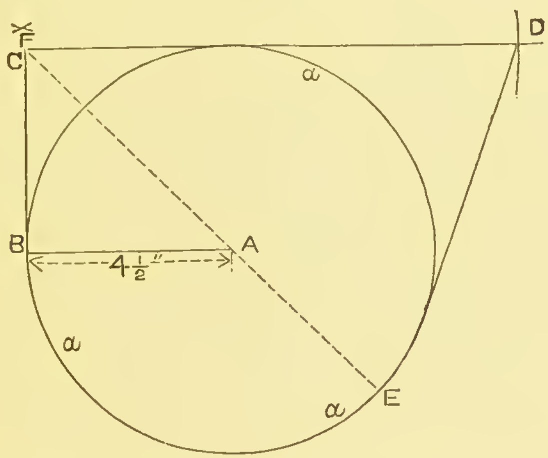
"Mr. Robert Smith denied that Mr. Hellyer was correct in his statement that non-society workmen in the plumbing trade were better workmen than society men. Why should they be? Society men had to rely upon themselves and upon the character of their work as much as non-society men. Mr. Hellyer had advocated the granting of certificates of competency to plumbers. Some years ago there was a serious strike and lock-out in the building trade upon the introduction of what was known at the time as the "Document." Such a certificate as was advocated by Mr. Hellyer would be neither more nor less than the "Document" in a new form, and if the suggestion were adopted, the working plumber would be entirely in the power and at the mercy of his employer. While there was some truth in Mr. Hellyer's assertion that young plumbers did not always have a proper opportunity of learning their trade when they were apprenticed in small shops, it should not be forgotten that in a small shop an apprentice would have a greater range and variety of work in all branches, whereas in large shops the principle of subdivision of labour was sure to be more or less thoroughly carried out, and the apprentice would most likely be kept almost entirely to that particular branch of work in which he showed most proficiency. He denied that the ∽-trap was superior to the D-trap, and claimed for the latter that, if properly made, it was self-cleansing. He thought Mr. Hellyer had been unduly severe in his strictures upon the poor working plumber, while he had "let down" Mr. Norman Shaw very gently—perhaps because Mr. Shaw was an

architect for whom Mr. Hellyer might hope to do work in the future.

"The Chairman here intimated that he thought Mr. Smith was going a little wide of the point in imputing personal motives.

"Mr. Smith thought he was justified in what he had said. He did not think much of the practicability of Mr. Hellyer's recommendation to use 2½-inch soil-pipes. Although the lectures had been very entertaining, he did not think that the audience had had one particle of knowledge imparted to them from beginning to end. ('Oh, oh!' laughter, and hisses.) He certainly had not gained one particle of information. The lectures had been of a most rudimentary kind."—*The Builder.*

"Mr. P. J. Davies fixed upon the platform a stand supporting a glass model of a D-trap, which, he said, he would show was as self-cleaning* as the ഗ-trap, if properly made. Placing a handful of pebbles in the receiver, he demonstrated that a flush of about one gallon of water from a pail would instantly carry them from the body of the trap into the drain. The experiment was repeated with a pocket-handkerchief and a bottleful of ink



with similar results, and led to some discussion as to the size of trap between Messrs. Hellyer and Davies, which, as they stood close to one another on the platform, and did not raise their voices, was not distinctly audible to the majority of those present, nor at the reporters' table. Mr. Davies also drew a diagram (a reduction of which we give above) showing a graphical method of

* See Table, p. 160.

striking out with compasses and T-square a D-trap of good form. He explained the process thus: To draw the face of a 9-inch trap, first describe a circle, *a a a*, of equal diameter, of course arrived at by taking a $4\frac{1}{2}$-inch radius, A B. On top of circle, *a*, *a*, *a*, and at a tangent to it, draw a right line, C D. Let fall a second line perpendicularly from C to B, again cutting the circle at a tangent at B. Then, placing foot of compass at the right angle at C, take a radius to extreme periphery of circle —*i.e.*, from C to E—and describe an arc from E to right line C D, which will give length and outline of cheek. The band of trap, Mr. Davies added, must be only sufficiently wide to admit of the dip, or, in other words, the diameter of dip and width of band must be equal."—*The Building News.*

"Mr. T. H. Court, speaking as a practical foreman of plumbers, criticised several of the statements made by Mr. Hellyer. They had been told, in an early lecture, that the plumber should provide himself with two pots of metal—one for underhand work and the other for general jobs. Would the labourer carry two heavy solder-pots for his mate? He knew that if a plumber asked him for two sorts of solder he should at once offer him his ticket for payment. Mr. Hellyer had recommended that the solder for underhand should be diluted with lead, and the next week the speaker had a pot of metal spoiled by a young man who followed this advice, and he had to issue an order that the first man who put lead in his solder would be discharged. A foreman worthy of the name ought to know by the appearance of a bar of solder whether it was of the right proportions. As these lectures were specially addressed to the younger plumbers, they should have been taught how to make solder, and how, if foul, it could be cleansed. If the time wasted during these lectures upon extraneous matters not pertaining to the subject had been devoted to practical or scientific points, the course would have been been of greater value. He was surprised to hear Mr. Hellyer recommend the making of very long joints. They were no stronger than short ones; if both were properly made, the appearance was no better, and the shorter one was more likely to be quickly, and therefore cleanly, wiped, and so had less chance of sweating. Mr. Hellyer condemned journeymen plumbers for much of the improper workmanship and the bad systems of ventilation; but in this he was hardly fair, as the men generally worked under orders. The speaker recently carried out a job in the City at an hotel, where the architect's specification left out all mention of ventilation to soil-pipes or cisterns. As a foreman, although he knew such a mode of fitting would lead to illness in the house, he would not have been justified in putting his employer to considerable expense to rectify

the omission ; but he did what he could—viz., he made representations on the subject, and was told to put the work in without ventilating-pipes. There was in the job a ¾-inch pipe, which, as a workman now in the room could testify, had to supply four urinals, four closets, three lavatories, two sinks, and a bath. Within a year or two he had to go to the same hotel, and was asked his opinion of the plumbing arrangements, when he pronounced them bad to the lowest degree, adding that he was condemning work carried out under his own supervision, but under protest. Would Mr. Hellyer blame the working plumber in cases like this ? He didn't consider Mr. Hellyer justified in standing before them as a sanitary engineer offering instruction to plumbers, yet at the same time admitting that he made and sold the very pan-closets he condemned. If Mr. Hellyer had been the master of a small jobbing shop, in a struggling position, there might have been some excuse ; but, as it was, he saw no justification."—*The Building News.*

"Mr. W. P. Buchan (of Glasgow) said he had not had the privilege of hearing Mr. Hellyer's lectures, but he was happy to have had the opportunity of reading the reports of them, and he thought very highly of them, notwithstanding the criticisms which he had heard from previous speakers. So far as he could judge from the lectures, as published, he approved of almost everything that Mr. Hellyer had said. He (Mr. Buchan) was at a loss to understand the favour in which the D-trap seemed to be held by some of the speakers, and their prejudice against the syphon-trap. Glasgow was no inconsiderable city, and a great deal of good plumbing work was to be found there ; yet, as a Glasgow-bred plumber of thirty years' experience, he never remembered seeing a D-trap used there. All the Glasgow plumbing was done with syphon-traps, and syphonage was easily preventable by means of ventilation. It seemed to be forgotten that the ventilating-pipe to a trap, if properly made and fixed, killed two birds with one stone, so to speak, for it prevented syphonage, and at the same time prevented the accumulation of foul gases, which would eat away the lead unless carried off. Mr. Davies's experiments with his D-trap were not to his (the speaker's) mind altogether conclusive, for pebbles and pocket-handkerchiefs could be more easily cleared out of a trap than urinary matter and flocculent particles of fæces. Much as was to be said against the D-trap, however, it was far safer to use it than to use a trapless closet. Where illness resulting in death arose from the use of trapless closets, the fixers of them ought to be found guilty of manslaughter. He thought that no one could defend the use of trapless closets upon any scientific or hygienic ground. Pan-closets were bad enough, but where they could not be removed

their evils could be mitigated by ventilating the containers, but with two pipes. While some architects were not blameless for bad plumbing, there were others who had done a great deal to promote good work. There were, he knew, many workmen in the trade who were only partially competent; but Mr. Hellyer's lectures were part of a movement designed to help every working plumber to become a first-class workman. He considered that plumbing was the leading trade connected with building, and that plumbers ought to be the best-paid workmen in the building trade. Upon the working plumber largely depended the health of many a household, and as he was often sent to do work without being supervised by a foreman, he should, when of proved competency and reliability, be remunerated for his work with some regard to the responsibility of his position."—*The Builder.*

"Mr. J. Vance said that sometimes when a working plumber who understood his business ventured to point out a defect or a bad arrangement in plumbing work proposed to be done, he was told, by architect or proprietor, as the case might be, 'Do as you are told; you are not paid for knowing anything about it, you are paid for doing the work according to instructions!' Personally he felt very much indebted to Mr. Hellyer for his lectures. He had only to say, in conclusion, that when architects or sanitary engineers came on a job to give instructions as to plumbing, they should see the plumber himself, and not give their instructions to the general foreman of works, who most likely knew nothing of plumbing work, and would therefore be unable to clearly explain their wishes. Instead of allowing their instructions about plumbing to be conveyed second-hand, architects and sanitary engineers would do well to see the plumber himself."—*The Builder.*

"Mr. H. H. Collins, F.R.I.B.A., said some mention had been made of the trapless closet, and having used it in his own house, with a large family, he must say it answered admirably. If placed in proximity to a sewer, it would no doubt be objectionable; but properly ventilated it was infinitely superior to other closets. It had no container, no D-trap, no apparatus to get out of order, and little brasswork to become corroded. There was, certainly, a tendency to accumulate a little filth beneath the pan; but he gave the housemaid some spirits of salt, with directions to cleanse it about once a week, and that kept it quite sweet. There was one objection about this closet to plumbers—he had never had it repaired. He feared architects, as a body, through carelessness, but not through ignorance, had neglected some practical matters in favour

of the artistic side of their profession, till there was some danger that specialists would take this engineering and sanitary work from their heads. In criticising their plans and specifications, however, it should be remembered that architects were not always their own masters, any more than was Mr. Hellyer. Mr. Norman Shaw, and other leading architects, and such plumbers as Mr. Hellyer, might be able to refuse to carry out work unless their ideas were followed, but the young and struggling architect or plumber couldn't take such high ground. The way in which the crassly-ignorant or obstinate client could best be convinced of his errors was by the delivery of such lectures as those of Mr. Hellyer, and the wide-spread discussion they gave rise to. When the public was fully educated, pan-closets and similar abominations would pass into limbo, and be only known as matters of history. He had regretted to hear a speaker early that evening say, in very ill-taste, that from all the lectures delivered by Mr. Hellyer he had not gained one particle of information. He was very sorry for that individual. (Loud applause.) He scorned to bestow that false praise which was but satire in disguise; but he must say that the efforts of a gentleman closely engaged in business who had given up so much of his time gratuitously to instruct others in the details of his and their trade, and to impart the benefit of his experience, deserved grateful recognition at the hands of plumbers. (Loud applause.) If Dr. Johnson's dictum were true, that we could learn something even from a fool, the gentleman who had complained of Mr. Hellyer's rudimentary instruction could not be said to have displayed a large amount either of wisdom, intuition, or experience."—*The Building News.*

"Mr. Lammas urged the formation of an institution for the encouragement, protection, and advancement of the plumbing trade—a place where the members could meet to read, think, and discuss methods and principles of work, and including, if possible, a small workshop, where the members could put their ideas into execution and to the test of practical experiment. He felt very much indebted to Mr. Hellyer for his lectures."—*The Builder.*

"Mr. Wise supported the suggestion made by the last speaker." —*The Builder.*

"Mr. Savory said that although, perhaps, all that had been said by Mr. Hellyer was not to be taken without question, he had laid down many principles which could not be controverted. It was desirable that the lectures should be published *in extenso* in a cheap form, together with a report of the discussion."—*The Builder.*

"The Chairman, in closing the discussion, said that when Mr. Ernest Turner suggested that the National Health Society should

arrange for a course of lectures to working plumbers upon the principles and practice of sanitary plumbing, the initial difficulty was to get a competent lecturer. He, knowing the name of Mr. Hellyer as that of the writer of the best practical work on plumbing, invited him to give the lectures, and after consideration he consented to do so, although very much occupied with business and not in the best of health. The lectures had been undertaken by Mr. Hellyer without any remuneration beyond that which was afforded him by the knowledge that they have aroused considerable thought and directed much attention to the subject. The laborious and complete way in which the lectures had been illustrated by diagrams was worthy of all praise. The lectures had been delivered not only in the presence of working plumbers, but in the presence of some of the most skilled and experienced judges of sanitary work in the country, and including Mr. Rogers Field, Mr. Ernest Turner, Mr. H. H. Collins, and Mr. Eassie, and he had the authority for saying that those gentlemen regarded Mr. Hellyer's lectures as being of very great value."—*The Builder.*

"Mr. Hellyer, in replying on the discussion, said that he was gratified to find that the remarks made by those who had spoken in the discussion were so largely in favour of the observations he had made in his lectures. With reference to Mr. Emptage's remarks on cowls, he would only say that his experience was that cowls were of advantage in hundreds of cases, as they helped to increase the up-current. He had tested * this at the cost of £200 or £300, and therefore was certain of what he advanced. With regard to non-society men *versus* society men, considered as workmen, he simply stated his conviction, based on experience, when he said that as a rule non-society men were the best workmen. He wanted the trade societies to be more careful in excluding incompetent men than they had been. He had no more feeling against society men than against non-society men, and had good workmen belonging to both classes in his employ. He was very glad if, as a result of his lectures, Mr. Davies had been able to improve the D-trap, but he (Mr. Hellyer) like a previous speaker, could not see the conclusiveness of the experiments which had been made with Mr. Davies's trap. He challenged the accuracy of Mr. Court's statement that anything said by him in the course of these lectures was calculated to do harm to young plumbers. With regard to using two pots of solder, he simply recommended that in large buildings or jobs two pots of solder should be in use: one for underhand joints—as coarser solder worked better for this kind

* See "The Plumber and Sanitary Houses," Chap. XXIII., on the merits o various cowls.

of joint—and one supplied with richer solder, for upright joints. tacks, and cistern-soldering, &c., the object being to save time, Time was an important element in work, and as an employer of labour he valued time. It frequently hinged upon time whether a master plumber made profit or no profit on a job. As to pan-closets, he had previously explained that he only supplied them under protest, when there was no help but to use them, as in the circumstances he had mentioned. As a matter of fact, irrespective of the job to which he had referred, his firm had almost entirely discarded their manufacture and use, and had not supplied more than thirty during the last three years. On all their circulars it was expressly stated beneath the illustration of the pan-closet that it was not an appliance to be recommended. He was gratified that Mr. Buchan should have supported by the weight of his experience what he (the lecturer) had said, for Mr. Buchan was well known throughout the country. Notwithstanding what Mr. Collins had said as to trapless closets, he (the lecturer) still stood by his condemnation of them. In conclusion, Mr. Hellyer said he looked upon sanitary plumbing as an important branch of Preventive Medicine, and, therefore, he regarded the efforts which were being made by members of the medical profession to render it more common as most disinterested and praiseworthy.

"The meeting closed with thanks to Mr. Hellyer and the chairman."—*The Builder.*

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